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WIDE DISPERSION MICROWAVE SPECTRUM ANALYZER MODEL SPA-3000

FS02

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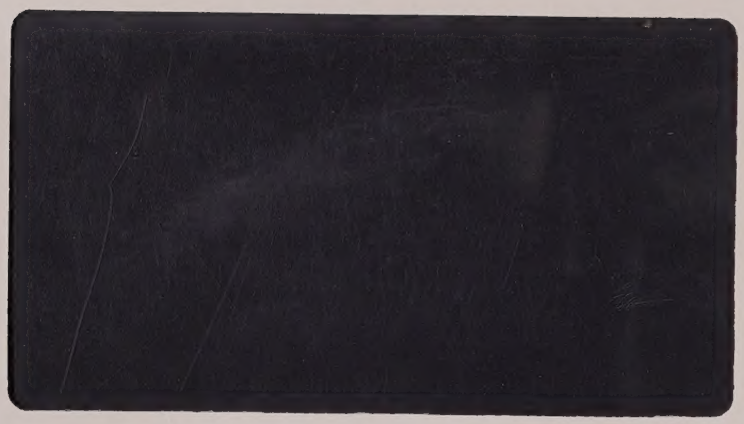

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INSTRUCTION MANUAL

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WIDE DISPERSION MICROWAVE

SPECTRUM ANALYZER

MODEL SPA-3000

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Creative Products for Test, Measurement, Analysis, Calibration

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*Except where a specific warranty period is stated in the operating manual

The Seller will not be liable for incidental or consequential damages. The Seller's sole liability shall be repair, replacement, or return of purchase price at our option. Warranty returns first must be authorized by the factory, and repairs or replacements (at our option) will be made without charge for instruments returned freight prepaid to the factory or authorized repair depot when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron Tubes, integrated circuits, semi-conductors, batteries, fuses, lamps, thermoelements and *Ratio Tran* potentiometers are excluded from Warranty coverage. If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, this warranty is VOID.

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8. Other comments

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Contact Ballantine Operation, P.O. Box 97, Boonton. New Jersey, 07005 for Ballantine instruments

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

MODEL SPA-3000 WIDE DISPERSION MICROWAVE SPECTRUM ANALYZER

Preface to Instruction Manual

GENERAL.

The two technical manuals contained in this handbook cover all of the equipment necessary to form a Model SPA-3000 Wide Dispersion Microwave Spectrum Analyzer, which consists of a Model MF-100 Main Frame and a Model RF-3000 Tuning Head.

DESCRIPTION.

The Model SPA-3000 Wide Dispersion Microwave Spectrum Analyzer is an extremely versatile universal broadband instrument with highly accurate calibration capabilities. The Model SPA-3000 covers the frequency range from 10 MHz to 40 GHz in nine bands. The tuning head incorporates a swept first local oscillator, highly efficient first mixers and the r-f circuitry necessary to convert the applied r-f signal under analysis to the center of the display unit's wideband i-f amplifier passband. Optional external mixers are available for use with the RF-3000 when operating in the 12.4-40 GHz ranges.

The Model MF-100 Main Frame contains the circuitry common to the latest of the SPA- series of spectrum analyzers. This solid-state assembly incorporates state-of-the-art wideband and variable bandwidth narrowband i-f amplifiers, a narrow swept local oscillator, a sequential detection logarithmic i-f amplifier as well as sweep and synchronization circuitry.

HANDBOOK USE.

Two technical manuals are provided under this cover; the first manual covers the Model RF-3000 Tuning Head and the other covers the Model MF-100 Main Frame. Section I of each manual describes the purpose and use of each unit and also provides, in tabulated form, the unit specifications. Because the tuning head performs the front-end function and determines system operation, those specifications which relate to overall system capabilities are covered in the tuning head manual; while only those specifications covering the presentation are covered in the the Main Frame manual.

The procedures for proper operation of the spectrum analyzer are dependent upon the tuning head employed with the main frame. Therefore, the operating procedures are contained in the Operation Section (Section II) of the tuning head manual.

Section III of each manual covers the theory of operation of that particular unit.

Section IV of each manual contains minimum performance standards, component location data, troubleshooting procedures, alignment procedures and parts removal and replacement procedures.

Schematic diagrams are provided in Section V of both manuals, and Section VI contains a complete electrical parts list.

WARNING

HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Learn the areas containing high voltage

in each piece of equipment

Be careful not to contact high-voltage connections

when installing or operating this equipment

Before working inside the equipment, turn power

off and ground points of high potential

before touching them

INSTRUCTION MANUAL

TUNING HEAD

MODEL RF-3000

Instruction Manual No. 110-5090

Serial No. _____

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BACKWARD WAVE OSCILLATOR WARRANTY

The BWO is warranted for 2500 hours of filament operation or one year from date of original shipment, whichever period ends first. If the BWO fails within this period, see the Warranty Claim and Adjustment Procedure, Microwave Tube Warranty Claim Information Form and Shipping Instructions at the rear of this manual. Remove total time indicator TT1 of -6.3 Volt BWO Filament Power Supply A5 and include with the BWO for warranty adjustment.

NOTE

When ordering a replacement BWO always order a replacement total time indicator (Singer Part No. 556147-245).

ADDITIONAL NOTES ON RESOLUTION

OPTIMUM RESOLUTION.

The most critical adjustment in the operation of a spectrum analyzer is the setting of the final IF bandwidth for optimum resolution; thereby allowing the operator to obtain the most accurate visual presentation of applied discrete signals.

Optimum resolution, however, is a function of both the selected dispersion and sweep time, and may be calculated from the equation

$$R \approx 1.5\sqrt{\frac{D}{T}}$$

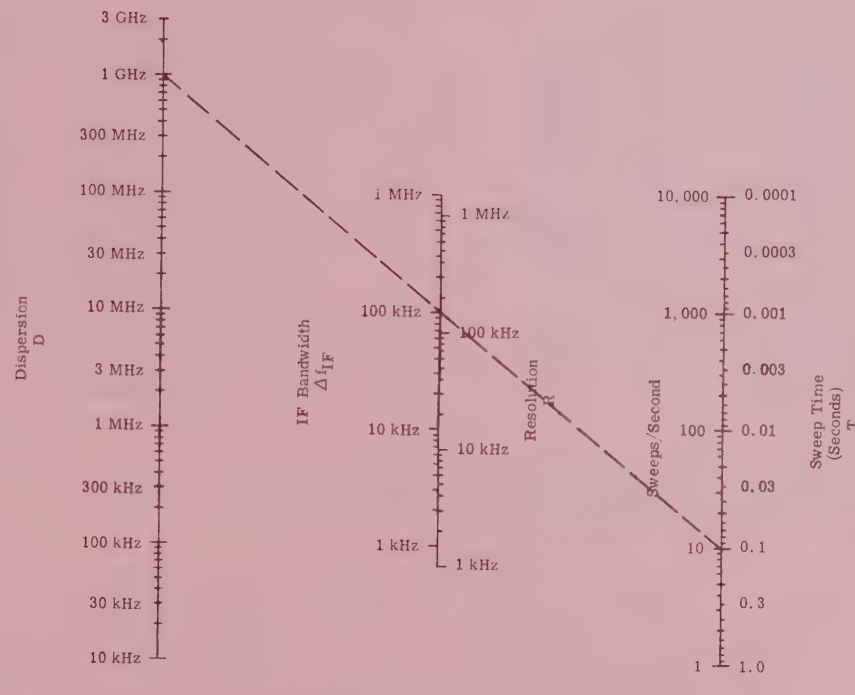
where R = optimum (minimum) resolution, in Hz,
D = selected dispersion, in Hz, and
T = selected sweep time, in seconds.

The nomograph of figure A is supplied to permit the operator to quickly determine the optimum resolution and required final IF bandwidth for given values of dispersion and sweep time.

Note that to achieve optimum resolution, the final IF bandwidth must be set to a value somewhat less than the calculated value of R; this factor compensates for the difference between "static" and "dynamic" bandwidths.

OVERRESOLVING.

Setting the final IF bandwidth much narrower than the value required for optimum resolution (overresolving) results in a loss in analyzer sensitivity and an apparent resolution much wider than the selected IF band-



EXAMPLE:

To determine the optimum resolution and proper IF bandwidth for a selected dispersion of 1 GHz (100 MHz/division) and sweep time of 100 milliseconds (10 mS/division), draw a straight line from the 1 GHz point of the dispersion D scale to the 0.1 second point of the sweep time T scale. This line intersects the resolution R scale at 150 kHz and the Δf_{IF} scale at 100 kHz. The BANDWIDTH switch should therefore be set to 100 kHz for optimum resolution at these particular settings of dispersion and sweep time.

Figure A. Optimum Resolution Nomograph

width. The loss in sensitivity due to overresolving is (see figure B) is given by

$$a_s = \left[1 + 0.195 \left(\frac{D}{T \Delta f_{IF}^2} \right)^2 \right]^{-1/4}$$

where a_s = response relative to that attained with zero dispersion and
Δf_{IF} = final IF bandwidth, in Hz.

The loss in resolving power (see figure C) is given by

$$\frac{R}{\Delta f_{IF}} = \left[1 + 0.195 \left(\frac{D}{T \Delta f_{IF}^2} \right)^2 \right]^{1/2}$$

where $\frac{R}{\Delta f_{IF}}$ = apparent bandwidth of the spectrum analyzer relative to the steady-state bandwidth.

The effect of overresolving can be illustrated by using the example of figure A. If, instead of using the final IF bandwidth of 100 kHz required for optimum resolution, the BANDWIDTH switch is set to 10 kHz, the normalized sweep velocity becomes 100. This overresolving produces a 16.5 dB loss in sensitivity (from figure B) and an apparent resolution of 450 kHz (from figure C).

UNDERRESOLVING.

Underresolving (setting the IF bandwidth much greater than that required for optimum resolution) has no effect on the display amplitude, but the resolving power is limited by the actual IF bandwidth.

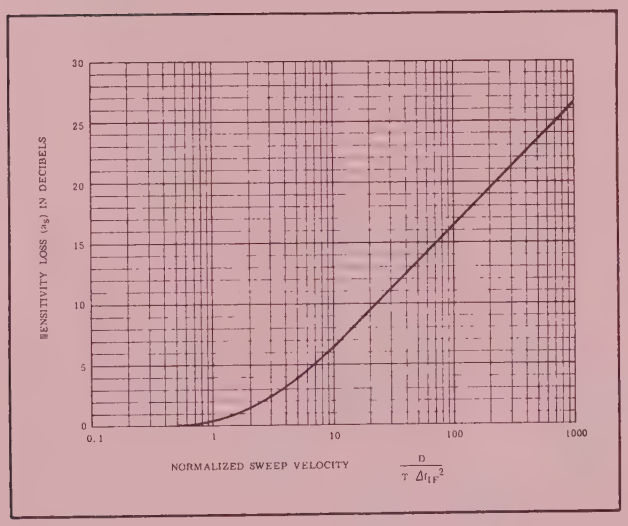


Figure B. Loss of Sensitivity Due to Overresolving

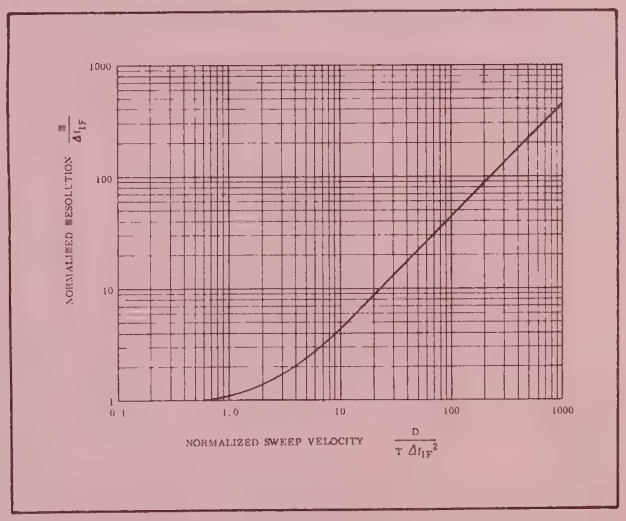


Figure C. Loss of Resolution Due to Overresolving

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Figure 1-1. Model SPA-3000 Wide Dispersion Microwave Spectrum Analyzer

SECTION I
INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides general information and operating instructions for the PANORAMIC* Model SPA-3000 Microwave Spectrum Analyzer (see figure 1-1), manufactured by The Singer Company - Instrumentation Division. This manual also includes the theory of operation, maintenance, schematic diagrams and parts list for the front end portion of the analyzer (Model RF-3000 Tuning Head).

Note

The general information, theory of operation and maintenance instructions for the Model MF-100 Main Frame portion of the spectrum analyzer is contained in the manual at the back half of this volume.

1-3. The information contained in this handbook reflects the standard Model RF-3000 Tuning Head and Model MF-100 Main Frame (hereafter referred to as the RF-3000 and Main Frame, respectively) which combine to form a Model SPA-3000 Microwave Spectrum Analyzer (hereafter referred to as the SPA-3000). Differences in equipment configuration, components, specifications and performance resulting from customer application requirements and/or The Singer Company's continuous product improvement program are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The RF-3000 is an ultrawide dispersion multiband tunable front end which, in conjunction with a Main Frame, enables the user to visually examine either the amplitude-frequency characteristics or amplitude-time characteristics of applied RF signals. Typical applications of the equipment are listed below.

a. Dynamic performance analysis of oscillators, generators and transmitters.

b. Spectrum monitoring of communications channels and radar frequencies.

c. Analyzing pulsed signals.

d. Analyzing spectra associated with amplitude-, frequency- and pulse-modulated signals.

e. Direct reading of power peak and null frequencies.

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f. Microwave equipment malfunction studies (e.g., spurious signals, instabilities, microphonics, etc.).

g. Analysis and reduction of EMI.

h. Multiplier testing and alignment.

i. Factory calibration of production RF equipment.

j. Harmonic and other out-of-band measurements.

k. Examination of cw signal drift, incidental fm and squegging.

l. Examining dynamic operating characteristics of microwave tubes and devices.

m. Checking for RF radiation and leakage.

n. Determining the presence and frequency of RF signals.

o. Use as a sensitive receiver to measure characteristics of microwave components or circuits (e.g., insertion loss and VSWR measurements).

p. Evaluating characteristics of wide range voltage-tuned oscillators.

1-6. Inquiries are invited regarding special applications of the SPA-3000 to particular customer requirements. Such inquiries should be directed to the attention of the Applications Engineering Department.

1-7. SUPPLIED AND OPTIONALLY AVAILABLE ACCESSORIES.

1-8. The SPA-3000 is shipped complete and is ready for use upon receipt. The complete SPA-3000 consists of the following items.

a. One (1) RF-3000.

b. One (1) MF-100.

c. One (1) dummy front panel (Singer Part No. 118-0530-001).

d. One (1) 30-inch multiconductor patch cable (Singer Part No. 102-9139-001) with 20-pin connectors at each end.

e. One (1) 30-inch coaxial IF patch cable (Singer Part No. 102-9200-361) with subminiature coaxial right-angle connectors at each end.

f. One (1) 11-pin interlock connector (P9, Singer Part No. 133-0109-001).

1-9. If only an RF-3000 was ordered (purchaser employing the Main Frame of either a SPA-100 or SPA-100A to complete the SPA-3000), only items a, b and d through f of paragraph 1-8 are furnished. Optionally available accessories, supplied only when specifically ordered, are listed and described in table 1-1.

1-10. SPECIFICATIONS.

1-11. The electrical and physical specifications of the SPA-3000 are listed in table 1-2.

TABLE 1-1. OPTIONALLY AVAILABLE ACCESSORIES

Nomenclature	Function
Model K_u-3000 Waveguide Mixer*	External waveguide mixer (mates with UG-419/U flange) for signals between 12.4 and 18 GHz.
Model K-3000 Waveguide Mixer*	External waveguide mixer (mates with UG-595/U flange) for signals between 18 and 26.5 GHz.
Model K_a-3000 Waveguide Mixer*	External waveguide mixer (mates with UG-599/U flange) for signals between 26.5 and 40 GHz.
CMF-100 Front Panel Covers	Protective cover for equipment front panel; provides storage space for accessories that are not being used.
Model RM-100 Rack Mounting Ears**	Permits mounting of equipment in a standard 19-inch rack.
Model RM-101 Rack Mounting Ears and Slides**	Permits slide-mounting of equipment in a standard 19-inch rack.
Connector (Singer Part No. 556146-754; Continental Connector Corp. Part No. SM20-20PGD)	20-pin connector which mates with AUXILIARY MODULE connector J2 on rear panel of Main Frame.
Connector and Hood (Singer Part Nos. 556146-750 and -758; Continental Connector Corp. Part Nos. SM11-20PGD and -20H-1)	Eleven-pin connector which mates with either auxiliary input/output connector J1 on rear panel of Main Frame or AUXILIARY MODULE connector J11 on rear panel of RF-3000.
Coaxial Connector (Singer Part No. 556147-019; Sealectro Corp. Part No. 50-11-001)	Coaxial connector which mates with auxiliary 60 MHz OUTPUT connector J11 on rear panel of Main Frame.
Model FL-3000 Band-Pass Filter Panel	Four panel-mounted, switch selectable band-pass filters employed to eliminate out-of-band multiple responses.
Model FL-3000A Band-Pass Filter Set*	Set of four band-pass filters (FL-3000-1, DC to 3 GHz; FL-3000-2, 3 to 6 GHz; FL-3000-3, 6 to 8 GHz; FL-3000-4, 8 to 10 GHz) employed to eliminate out-of-band multiple responses.

* 38-inch coaxial cable 102-9112-005 furnished with one or more mixer(s) for coupling to RF-3000 SIGNAL INPUT 12.4-40 GHz jack.
** Two sets required.
*** Individual filters available as required.

TABLE 1-2. SPECIFICATIONS

Parameter	Specification
Frequency range	10 MHz to 40 GHz in 9 bands
Frequency accuracy	±1% of L. O. frequency
Sensitivity[1]	See sensitivity table below
First local oscillator	BWO tunable from 4 to 8.08 GHz
Incidental FM (LO fundamental)	Phase locked - 100 Hz peak-to-peak, maximum Not locked - 40 kHz peak-to-peak, maximum
Noise sidebands	Greater than 60 dB below cw signal level 30 kHz or more away from signal, using fundamental mixing with 1 kHz bandwidth
Dispersion:	
Range	12 calibrated dispersions from 10 kHz to 3 GHz in 1-3-10 sequence; continuously adjustable between steps. Zero dispersion capability for receiver operation and time domain analysis
Accuracy	±5% for dispersion ranges up to 300 kHz/div; ±5% ±2 MHz for dispersion ranges above 1 MHz/div
Phase lock	Internal phase lock capability continuously tunable for stabilizing BWO for dispersions up to 3 MHz. Indicator lamp illuminates when BWO is phase-locked. Phase lock not swept to provide maximum stability
Markers (auto calibration)	
IF	Internal 160 MHz center frequency marker with selectable 1 MHz modulation capability provided for calibration and alignment. External marker modulation from 1 kHz to 1 MHz (operative only for dispersions up to 3 MHz)
RF	11 markers, at 400 MHz increments, on local oscillator fundamental 4 to 8 GHz range
Attenuation:	
RF	0 to 60 dB in 10-dB steps (10 MHz to 12.4 GHz)
IF	0 to 69 dB in 1-dB steps; accuracy of ±0.05 dB/dB
Intermediate frequencies	4 GHz, 2.08 GHz, 160 MHz, 60 MHz and 6.5 MHz

Sensitivity[1]

Frequency Range	L. O. Harmonic	Minimum Sensitivity	Maximum Dispersion	Response (Full Range)
10 MHz to 3.5 GHz	1st	-105 dBm	3 GHz	±3.0 dB[3]
3 to 6 GHz	1st	-105 dBm	3 GHz	±3.0 dB
4.5 to 10 GHz	2nd	-100 dBm	3 GHz	±4.5 dB
9 to 12.4 GHz	3rd	-95 dBm	3 GHz	±3.5 dB
12.4 to 15.5 GHz[2]	3rd	-95 dBm	3 GHz	
15 to 21 GHz[2]	4th	-90 dBm	3 GHz	
20 to 26.5 GHz[2]	5th	-85 dBm	3 GHz	
26.5 to 31 GHz[2]	6th	-80 dBm	3 GHz	
30 to 40 GHz[2]	7th	-75 dBm	3 GHz	

1. Sensitivity defined as signal plus noise equal to twice noise (S+N=2N) at 1 kHz bandwidth, power display
2. In conjunction with optionally available waveguide mixers
3. From 1 to 3.5 GHz. Response from 0.01 to 1 GHz is ±3.5 dB

TABLE 1-2. SPECIFICATIONS (Cont'd)

Parameter	Specification
Image separation	4. 16 or 8 GHz
Multiple responses	None within full 3 GHz dispersion up to 9 GHz; none within dispersions of 2 GHz from 9 to 40 GHz
Residual responses (no input signal)	Less than -90 dBm referred to signal input on fundamental mixing
Harmonic identifier	Single pushbutton switch provided to assure proper band selection
Bandwidths:	
Fixed	Six calibrated steps of 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz 1 MHz and AUTO (automatically selects bandwidth for optimum CW resolution)
Variable	1 to 100 kHz, continuously adjustable
Video filter	Tracked with variable bandwidth; independently adjustable in calibrated bandwidth step positions
Variable IF gain	20 dB, minimum
Amplitude scales	
Log	60 dB (on screen); accuracy - ±2 dB
Lin	Relative voltage; accuracy - ±3% of full-scale
Pwr	Relative power; accuracy - ±5% of full-scale
CRT	5ADP31M; 7. 5 x 10 cm graticule

SECTION II
OPERATION

2-1. GENERAL.

2-2. This section contains instructions for the installation and operation of the SPA-3000. It is strongly recommended that the operator become thoroughly familiar with the material in this section before attempting to operate the equipment. Failure to do so may compromise the great versatility that has been engineered into the instrument.

2-3. INSTALLATION.

2-4. The SPA-3000 is shipped complete and is ready for use upon receipt. After the equipment has been unpacked, check the contents of all shipping containers against the packing invoice to ascertain that the order is complete.

2-5. INSPECTION. Examine the equipment for indications of damage which may have occurred during shipment. Check all front panel controls for freedom of movement, full travel and positive-detent locking. Note any evidence indicating that the equipment has sustained a severe mechanical shock. Check the condition of all accessories, both standard and optional, furnished as part of the order.

2-6. BENCH MOUNTING. The SPA-3000 should be mounted on a sturdy, vibration-free surface. Carefully place the RF-3000 on the bench surface so that the equipment side panel is parallel to, and a few inches from, the edge of the bench. Place the Main Frame atop the RF-3000. Interconnect the equipment as directed below.

Note

If the Main Frame employed in the SPA-3000 system has either a Model RF-100 or RF-100A Tuning Head installed, disconnect the short IF patch cable from between the rear panel IF INPUT and IF OUTPUT connectors and also disconnect jumper plug P9 from the rear panel AUXILIARY MODULE J2 multipin connector. Store P9 in a safe place, available for use when operation of the SPA-100 or SPA-100A is required.

a. Connect multiconductor patch cable 102-9139-001 (supplied accessory) between the RF-3000 rear panel to J2 MF-100 connector and the Main Frame rear panel AUXILIARY MODULE J2 connector.

b. Connect coaxial IF patch cable 102-9200-361 (supplied accessory) between the RF-3000 rear panel IF OUTPUT jack and the Main Frame rear panel IF INPUT jack.

c. Rotate the Main Frame SCALE ILLUMINATION control fully counterclockwise to PWR OFF and depress the RF-3000 SYSTEM POWER (red) pushbutton switch to ascertain that it is in the released (out) position.

d. Determine both the frequency and voltage of the power available at the power output receptacle.

CAUTION

The RF-3000 will operate from a 115 or 230 volt, 47 to 63 Hz power line. Check both the line voltage and frequency before coupling the SPA-3000 to line power.

The Main Frame and RF-3000 are both normally factory-shipped with line protective fuses rated at 1.25 amperes (delay type) and the rear panel 115/230 volt switches set for 115 volt operation. If the equipment is to be powered from a 230-volt line, replace these fuses with delay-type fuses rated at 7/10 amperes at 230 volts and conspicuously tag the equipment that it has been modified for 230-volt line operation.

e. If the equipment is to be operated from a 230-volt line, replace the existing line protective fuses with fuses rated at 7/10 amperes at 230 volts. Set the rear panel 115V/230V switches of both the Main Frame and RF-3000 to 230V.

WARNING

THE SPA-3000 IS DESIGNED FOR OPERATION FROM A POLARIZED THREE-TERMINAL (ONE GROUND) POWER RECEPTACLE. TO ELIMINATE THE POTENTIAL SHOCK HAZARD TO OPERATING PERSONNEL, A THREE-PRONG TO TWO-PRONG ADAPTER SHOULD BE EMPLOYED TO PRESERVE THIS PROTECTION FEATURE. CONNECT THE GREEN PIGTAIL LEAD OF THE ADAPTER TO POWER RECEPTACLE GROUND.

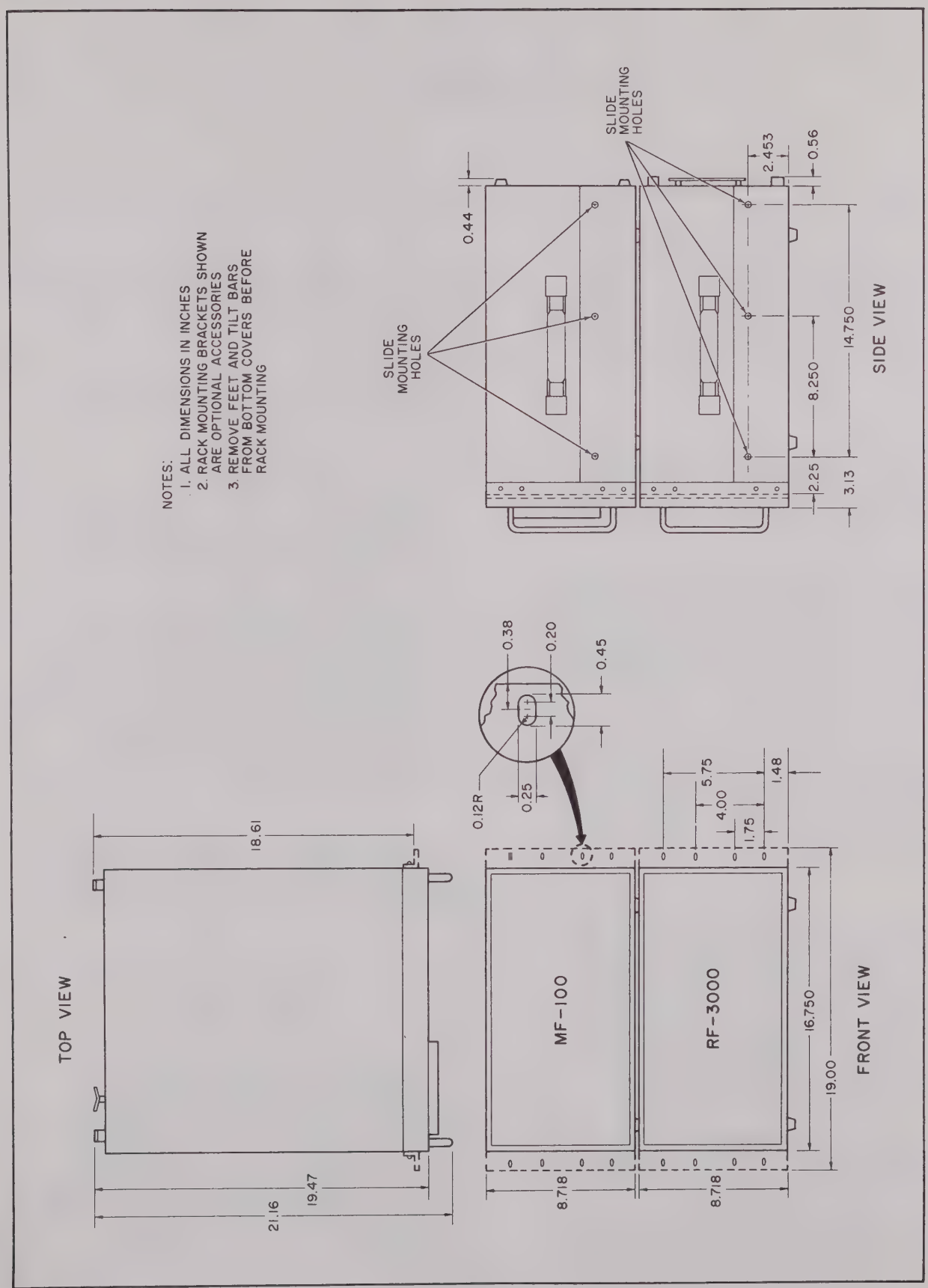


Figure 2-1. Installation Outline Drawing

f. Connect the RF-3000 power cord (through an adapter, if required) to the power outlet. Connect the Main Frame power cord to either the power outlet (through an adapter, if required) or to spare power receptacle J10 located on the rear panel of the RF-3000. Note that J10 is not switched.

g. Carefully slide the equipment so that its front panel is parallel to, and a few inches from, the edge of the bench.

2-7. RACK MOUNTING. To install the SPA-3000 in a standard 19-inch rack, proceed as directed in the following steps.

a. Secure a set of rack mounting ears to both the RF-3000 and Main Frame. (See figure 2-1.)

b. Install angle brackets on the rack to support the weight at the rear of each unit. Remove the feet and tilt bar from the bottom cover of each unit.

c. Install the equipment into the rack and secure each unit to the rack frame.

d. Connect the RF-3000 to the Main Frame and couple the SPA-3000 to line power as detailed in steps a through f of paragraph 2-6.

2-8. To install the SPA-3000 in a standard 19-inch rack on slide mounts, proceed as directed below.

a. Secure a set of rack mounting ears to both the RF-3000 and the Main Frame. (See figure 2-1.)

b. Separate the rack mounting slides and secure the rack members of the slides to the rack walls. Secure the instrument members of the slides to the sides of the RF-3000 and Main Frame, placing the separator between the slide and instrument.

c. Remove the feet and tilt bar from the bottom cover of each unit.

d. Install the equipment into the rack and secure each unit to the rack frame. Note that there should be a free flow of air around the equipment since the RF-3000 is blower cooled.

e. Connect the RF-3000 to the Main Frame and couple the SPA-3000 to line power as directed in steps a through f of paragraph 2-6.

2-9. OPERATING CONTROLS, INDICATORS AND CONNECTORS.

2-10. All controls, indicators and connectors necessary for the operation of the SPA-3000 are located on the RF-3000 and Main Frame front and rear panels, as illustrated in figure 2-2; their functions are described in table 2-1.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

Control, Indicator or Connector	Figure 2-2 Index Number	Function
Main Frame		
H SIZE screwdriver control	1	Adjusts length of CRT trace.
H POS screwdriver control	2	Adjusts the horizontal positioning of the trace.
V POS screwdriver control	3	Adjusts the vertical positioning of the trace.
SCALE ILLUMINATION control and switch	4	Control adjusts CRT graticule illumination. When control is set fully counterclockwise to PWR OFF, Main Frame is de-energized.
FOCUS control	5	Permits focusing of the CRT display.
BRIGHTNESS control	6	Adjusts the intensity of the CRT display.
INTENSIFIER control	7	Allows intensification of displayed video pulses while blanking baseline and low-level noise.
CRT display	8	Cathode ray tube display with a calibrated graticule scale having 10 horizontal and seven vertical divisions.

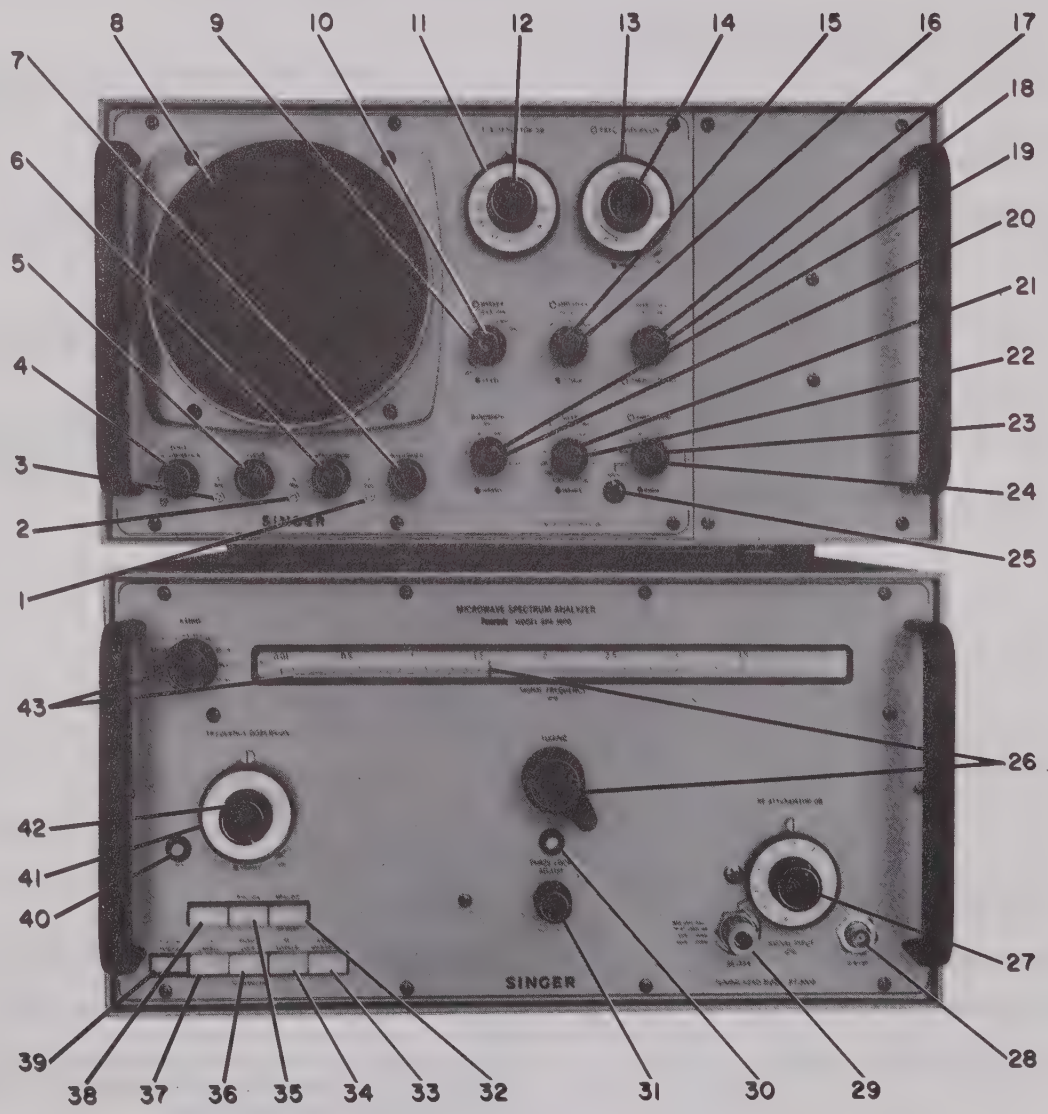


Figure 2-2. Operating Controls, Indicators and Connectors

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
Main Frame (Cont'd)		
MARKER MODULATION switch	9	Permits the operator to select an IF marker, as follows, when the dispersion is set to 300 kHz/div or less: EXT - Center frequency marker is modulated by an external signal source to provide sidebands at frequency increments determined by the source output frequency. OFF - Unmodulated internal center frequency marker is displayed on the CRT. 10 MHz - Center frequency marker is modulated by an internal oscillator to provide sidebands at 10 MHz intervals. 1 MHz - Center frequency marker is modulated by an internal oscillator to provide sidebands at 1 MHz intervals.
MARKER LEVEL control	10	Permits the operator to adjust the level of the selected marker display on the CRT. The marker may be unmodulated, modulated by internal circuitry to provide 1 MHz sidebands or modulated by an external source. When the control is rotated fully ccw to OFF, the marker generation circuitry is disabled.
IF ATTENUATOR decades switch	11	Permits attenuation (0 to 60 dB in 10 dB steps) of the IF input to the Main Frame.
IF ATTENUATOR units switch	12	Permits attenuation (0 to 9 dB in 1 dB steps) of the IF input to the Main Frame.
FREQ DISPERSION switch	13	Not used in the operation of the SPA-3000.
FREQ DISPERSION VARIABLE control	14	Not used in the operation of the SPA-3000.
AMPLITUDE SCALE switch	15	Enables the operator to select a 60 dB logarithmic display (LOG), linear display (LIN) or a power display (PWR).
IF GAIN control	16	Adjusts Main Frame IF gain to enable calibration of the display against a reference input signal.
SIGNAL FREQ POSITION f_o COARSE control	17	Enables the operator to place the IF center frequency marker at the f_o vertical line of the graticule.
SIGNAL FREQ POSITION f_o FINE control	18	Vernier adjustment which, in conjunction with the SIGNAL FREQ POSITION f_o COARSE control, enables the operator to place the IF center frequency marker at the f_o vertical line of the graticule.
BANDWIDTH switch	19	Enables the operator to select any one of six calibrated IF bandwidths (1 kHz to 1 MHz), a continuously adjustable IF bandwidth from 1 to 100 kHz (VAR) and an automatically selected IF bandwidth (AUTO) for proper resolution of displayed signals.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
Main Frame (Cont'd)		
BANDWIDTH VARIABLE control	20	Provides continuous uncalibrated adjustment of the IF and video bandwidth between 1 and 100 kHz when the BANDWIDTH switch is set to VAR; provides independent video filtering for BANDWIDTH switch settings of 1, 3, 10, 30 and 100 kHz and AUTO.
SWEEP switch	21	Permits the operator to select any one of eleven calibrated sweep times (from 10 microseconds per division to 1 second per division in a 1-3-10 sequence).
SWEEP VARIABLE control	22	Permits vernier increasing of the selected sweep time up to at least 30 seconds.
SWEEP/SYNC switch	23	Permits the operator to select the desired sweep mode as detailed below. SINGLE (black) sweep - Single sweep is initiated by the momentary depression of the SINGLE pushbutton switch. MAN (Black) sweep - Sweep position determined by the MANUAL control. EXT (black) sweep - Sweep determined by an externally generated signal applied to rear panel connector J1-E. INT (black) sweep - Sweep is free-running. EXT (red) sync - Sweep is triggered by an externally generated signal applied to rear panel connector J1-D. INT (red) sync - Sweep is triggered by detected video signal. LINE USE (black) - Sweep is synchronized to power line frequency. LINE CAL (black) - Employed when calibrating the video circuitry during maintenance operations and to indicate the sweep time when the SWEEP VARIABLE control is not set fully clockwise to CAL.
MANUAL control	24	Permits manual scanning of the displayed spectrum. This control is operative only when the SWEEP/SYNC switch is set to MAN.
SINGLE pushbutton switch	25	Initiates a single sweep when momentarily depressed. This switch is operative only when the SWEEP/SYNC switch is set to SINGLE.
60 MHz OUTPUT jack	Rear Panel	Connector which couples predetected 60 MHz IF signal to auxiliary test equipment.
IF OUTPUT jack	Rear Panel	Not used in the operation of the SPA-3000.
IF INPUT jack	Rear Panel	Connector which couples the 160 MHz output of the RF-3000 to the IF circuitry within the Main Frame.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
Main Frame (Cont'd)		
AUXILIARY MODULE connector J2	Rear Panel	Provides the necessary interlocks for connection to the RF-3000.
Auxiliary Connector J1	Rear Panel	Connector which couples horizontal and vertical outputs from the Main Frame to accessory recording instruments and couples externally generated sync, sweep signals and marker modulation inputs to the Main Frame.
+300, +100, +12, GND and -12 test points	Rear Panel	Provides accessible test points for monitoring internally developed power supply voltage levels.
F1 and F2 fuseholders	Rear Panel	House line protective fuses.
115V/230V switch	Rear Panel	Enables the equipment to operate from either 115 volt or 230 volt power lines.
RF-3000		
TUNING control and pointer	26	Tunes the spectrum analyzer to the desired signal frequency, as indicated by the index pointer on the selected frequency range scale.
RF ATTENUATOR switch	27	Permits attenuation (0 to 60 dB in 10 dB steps) of applied signals coupled to the SIGNAL INPUT .01-12.4 GHz jack.
SIGNAL INPUT 12.4-40 GHz jack	28	Connector which simultaneously couples the local oscillator output to, and the first IF output from, external waveguide mixers.
SIGNAL INPUT .01-12.4 GHz jack	29	Connector which accepts applied signals within the frequency range from 10 MHz to 12.4 GHz.
PHASE LOCK ADJUST indicator	30	Illuminates when the first local oscillator is frequency stabilized by means of the PHASE LOCK ADJUST control. Phase lock circuitry, which is continuously tunable, is operative only when the PHASE LOCK, kHz and/or 0 pushbutton switches are depressed.
PHASE LOCK ADJUST control	31	Permits the operator to frequency stabilize the first local oscillator during narrow dispersion (3 MHz or less) operation.
MHz/DIV pushbutton switch	32	Enables the operator, in conjunction with the FREQUENCY DISPERSION switch, to select calibrated display dispersions from 10 MHz to 3 GHz.
SIGNAL IDENTIFIER pushbutton switch	33	Momentary action switch which, in conjunction with the FREQUENCY DISPERSION switch, FREQUENCY DISPERSION VARIABLE control and MHz/DIV (SIG IDENT) pushbutton switch, enables the operator to ascertain that the RANGE switch is set to the proper band and that the signal being viewed on the CRT is not an image response.
RF MARKER pushbutton switch	34	Permits the operator to establish RF markers at 400 MHz intervals on local oscillator fundamental 4 to 8 GHz range.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
RF-3000 (Cont'd)		
kHz/DIV pushbutton switch	35	Enables the operator, in conjunction with the FREQUENCY DISPERSION switch, to select calibrated display dispersions from 10 kHz to 3 MHz.
PHASE LOCK (TO 300 kHz/DIV) pushbutton switch	36	Energizes the phase lock circuitry which enables the operator to frequency stabilize the first local oscillator during narrow dispersion (3 MHz or less) operation.
LO ENABLE pushbutton switch	37	Couples anode voltage to first local oscillator. Enables operator to remove anode voltage during standby condition.
0 pushbutton	38	Enables operator to use the SPA-3000 as a receiver and synchroscope.
SYSTEM POWER pushbutton switch	39	Couples line power to RF-3000.
UNCAL indicator	40	Illuminates to indicate uncalibrated dispersion condition (FREQUENCY DISPERSION VARIABLE control not rotated fully clockwise to CAL) or inoperative condition of signal identification circuitry (SIGNAL IDENTIFIER pushbutton switch depressed when PHASE LOCK, 0 or kHz/DIV pushbutton switch is depressed or FREQUENCY DISPERSION switch is set to any position other than 1 (SIG IDENT).
FREQUENCY DISPERSION pushbutton switch	41	Enables the operator to select, in conjunction with either the kHz/DIV or MHz/DIV pushbutton switch, calibrated display dispersions from 10 kHz to 3 GHz in a 1-3-10 sequence.
FREQUENCY DISPERSION VARIABLE control	42	Vernier control which, when rotated from its fully clockwise CAL position, permits the operator to reduce the dispersion selected by the setting of the FREQUENCY DISPERSION switch, thereby expanding the CRT presentation for closer signal examination.
RANGE switch and SIGNAL FREQUENCY GHz scale	43	Permits the operator to select the tuning band and associated scale compatible with the frequency of the applied signal under analysis. The frequency range of these bands are listed below. Band 1 - 0.01 to 3.5 GHz Band 2 - 3.00 to 6.0 GHz Band 3 - 4.50 to 10.0 GHz Band 4 - 9.00 to 12.4 GHz Band 5 - 12.40 to 15.5 GHz Band 6 - 15.00 to 21.0 GHz Band 7 - 20.00 to 26.5 GHz Band 8 - 26.50 to 31.0 GHz Band 9 - 30.00 to 40.0 GHz
IF OUTPUT jack	Rear Panel	Connector which couples the 160 MHz output of the RF-3000 to the IF circuitry within the Main Frame.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
RF-3000 (Cont'd)		
TO J2 MF-100 connector	Rear Panel	Provides necessary interlocks for connection to the Main Frame.
AUXILIARY MODULE connector and shorting plug	Rear Panel	Provides necessary interlocks for operation of RF-3000.
-12V, -6.3V, GND, +12V, +180V and ANODE test points	Rear Panel	Provides accessible test points for monitoring internally developed power supply voltage levels.
F1 and F2 fuseholders	Rear Panel	House line protective fuses.
115V/230V switch	Rear Panel	Enables the RF-3000 to operate from either 115 volt or 230 volt power lines.
Spare Power Receptacle	Rear Panel	Provides source of unswitched line power for auxiliary equipment.

2-11. PRELIMINARY ADJUSTMENTS.

2-12. After the SPA-3000 has been coupled to the power line as directed in paragraph 2-3, perform the preliminary adjustments below to prepare the equipment for operation.

a. Rotate the Main Frame SCALE ILLUMINATION control clockwise from its PWR OFF setting; the Main Frame is now energized. Adjust the control to obtain the desired CRT graticule scale illumination.

b. Ascertain that the RF-3000 LO ENABLE pushbutton switch is in the released (out) position and depress the red SYSTEM POWER pushbutton switch; the RF-3000 is now energized.

c. Allow the equipment to warm up for at least 10 minutes so that the BWO within the RF-3000 may stabilize. During this warmup period, set the front panel controls as listed in table 2-2. Note that controls not specifically referenced in the table may be set to any arbitrary position.

d. Adjust the FOCUS and BRIGHTNESS controls to obtain a sharply focused and clearly visible trace.

e. Rotate the IF GAIN control clockwise to obtain a noise display approximately one division high.

f. Rotate the MARKER LEVEL control clockwise from its OFF position so that the display rises between two and three divisions.

g. Adjust the SIGNAL FREQ position f_o COARSE and FINE controls to maximize the base line rise.

h. Alternately adjust both the H SIZE and H POS screwdriver controls, if necessary, to obtain a display that is centered horizontally on the CRT graticule and overlaps the extreme left and right vertical lines by one-quarter division.

i. Rotate the MARKER LEVEL control fully counterclockwise to OFF, rotate the IF GAIN control fully counterclockwise and, if necessary, adjust the V POS screwdriver control so that the trace coincides with the lowest horizontal graticule line.

j. With the MHz/DIV pushbutton switch depressed, set the BANDWIDTH switch to 1000 kHz and adjust the IF GAIN control to obtain a noise display one division high. The SPA-3000 is now ready for operation.

2-13. GENERAL OPERATING PROCEDURES.

2-14. SCANNING FOR SIGNALS. To scan the coaxial input frequency range of 10 MHz to 12.4 GHz for applied signals, proceed as directed in steps a through f. For applied signals within the waveguide input frequency range of 12.4 to 40 GHz, proceed as directed in paragraph 2-15.

a. After power has been applied to the equipment and the preliminary adjustments of paragraph 2-11 have been performed, set the RANGE switch to .01-3.5 GHz.

b. Rotate the TUNING control to obtain a pointer indication of 1.5 on the SIGNAL FREQUENCY GHz scale. Note the appearance of a zero pip at the extreme left graticule vertical line.

TABLE 2-2. INITIAL CONTROL SETTINGS FOR PRELIMINARY ADJUSTMENT PROCEDURES

Control	Setting
Main Frame	
FOCUS control	Mid-range
BRIGHTNESS control	Mid-range
INTENSIFIER control	Fully ccw
IF ATTENUATOR dB switches	00
MARKER MODULATION switch	OFF
MARKER LEVEL control	Fully ccw (OFF)
AMPLITUDE SCALE switch	LOG
IF GAIN control	Fully ccw
SIGNAL FREQ POSITION f_0 COARSE and FINE controls	Mid-range
BANDWIDTH switch	100 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV (black)
SWEEP VARIABLE control	Fully cw (CAL)
SWEEP/SYNC switch	INT (black)
RF-3000	
MHz/DIV pushbutton switch	Depressed
FREQUENCY DISPERSION switch	300
FREQUENCY DISPERSION VARIABLE control	Fully cw (CAL)
LO ENABLE pushbutton switch	Depressed
PHASE LOCK pushbutton switch*	Released
RF ATTENUATOR switch	0 dB
RF MARKER pushbutton switch*	Released

*a. If either the PHASE LOCK (TO 300 kHz/DIV) or RF MARKER pushbutton switch is depressed, release can be achieved by carefully depressing the released switch until pop out occurs.

b. Should both switches be depressed simultaneously, release can be achieved by first depressing one switch further in to release the other and then performing a above.

CAUTION

The maximum safe total input power level of the applied signal is a function of the power dissipation limits of both the input attenuator and first mixer diode. Do not exceed the input levels tabulated below as a function of RF ATTENUATOR dB switch setting.

RF ATTENUATOR dB Switch Setting	Maximum Safe Input Power Level
0	+10 dBm
10	+20 dBm
20 to 60	+30 dBm

Note

The maximum power level (at the input to the first mixer) of individual cw signals should not exceed -30 dBm. Signals above this level will cause distortion and the generation of spurious responses.

c. Couple the signal under analysis to the SIGNAL INPUT .01-12.4 GHz jack. Note the appearance of any signal pips. (The pip at the extreme left graticule vertical line represents local oscillator feedthrough at 4 GHz, i.e., "zero pip," and should not be mistaken for an applied signal.)

Note

A rise of the entire display base line is indicative of an applied signal at or near 4 GHz (refer to paragraph 2-52).

d. Slowly rotate the TUNING control clockwise to obtain a pointer indication of 2.5 on the SIGNAL FREQUENCY GHz scale. Note that the pips on the CRT display move to the left as the TUNING control is rotated clockwise. Observe the CRT display.

e. The pips appearing in the displays of steps c and e represent the total signal content within the coaxial input frequency range. (Refer to paragraph 2-47.) To view an individual signal component on the correct frequency band, proceed as directed in the following additional steps.

1. Adjust the TUNING control so that the signal of interest is centered on the CRT graticule f_0 vertical line.

2. Set the BANDWIDTH switch to 100 kHz, the FREQUENCY DISPERSION switch to 1 (SIG IDENT) and, if necessary, readjust the TUNING control to maintain the display centered on the CRT graticule.

3. With the MHz/DIV pushbutton switch still depressed and the FREQUENCY DISPERSION VARIABLE control rotated fully clockwise to CAL,

momentarily depress the SIGNAL IDENTIFIER pushbutton switch and note both the direction and amount that the display shifts.

4. If the display shifts to the right, an image response is being observed. If the display shifts one division to the left, the signal is being viewed on the correct (fundamental mixing) band.

Note

If the TUNING pointer indicates beyond 3.5 on the SIGNAL FREQUENCY GHz scale and the signal pip shifts one division to the left when the SIGNAL IDENTIFIER pushbutton switch is depressed, the signal should be observed on band 2. Extrapolate the signal frequency from the linear SIGNAL FREQUENCY GHz scale, set the RANGE switch to 3-6 GHz and adjust the TUNING control to center the display on the graticule.

5. If the display shifts less than one division to the left, the signal is being viewed on the wrong band. Set the RANGE switch to 4.5-10 GHz and repeat step 3. If the display shifts one division to the left, the signal is being viewed on the correct band; if less than one division to the left, set the RANGE switch to 9-12.4 GHz.

Note

If the TUNING pointer indicates below 4.5 on the SIGNAL FREQUENCY GHz scale and the signal pip shifts one division to the left when the SIGNAL IDENTIFIER pushbutton switch is depressed, the signal should be observed on band 2. Extrapolate the signal frequency from the linear SIGNAL FREQUENCY GHz scale, set the RANGE switch to 3-6 GHz and adjust the TUNING control to center the display on the graticule.

2-15. To view an applied signal on the proper waveguide input band, apply power to the equipment and perform the preliminary adjustments as directed in paragraph 2-11 and then proceed as indicated below.

a. Set the RANGE switch to the position corresponding to the particular waveguide frequency band of interest.

CAUTION

The maximum safe total input power level applied to the external waveguide mixer should not exceed +10 dBm.

Note

The maximum power level of an individual cw signal should not exceed -30 dBm. Signals above this level will cause distortion and the generation of spurious responses.

b. Couple the appropriate waveguide mixer to the SIGNAL INPUT 12.4-40 GHz jack via mixer patch cable 102-9112-005. Connect the waveguide mixer to the system under analysis using transitions and padding as required.

c. Adjust the TUNING control to center the signal of interest on the graticule.

Note

For displays free of multiple responses (refer to paragraph 2-47) the maximum frequency dispersion should be limited to 2 GHz.

2-16. OBTAINING PROPER RESOLUTION. At wide bandwidths, input signals having a small frequency difference tend to merge into and mask each other. The ability of the analyzer to separate and identify individual signals depends upon two factors: the scanning velocity (the selected frequency dispersion in MHz/DIV or kHz/DIV divided by the selected sweep time in MS/DIV and the bandwidth of the IF amplifier stages (see figure 2-3). For any given scanning velocity, there is a corresponding IF bandwidth for optimum resolution: the relationship being

$$R \approx 1.5 \sqrt{\frac{D}{T}}$$

where

R is the bandwidth for optimum resolution (in Hz).

D is the selected dispersion (in Hz) and

T is the selected sweep time (in seconds)

The BANDWIDTH switch should be set to a value somewhat less than that calculated for R for optimum resolution. The scanning velocity can be reduced by decreasing the frequency dispersion scanned by each sweep or by increasing the time for one sweep. Reduction of the IF bandwidth improves the resolution (the ability of the analyzer to separate closely-spaced signal components). If the frequency of a low amplitude signal is close to the frequency of a larger amplitude signal, the smaller pip will be masked by the skirt of the larger pip (the amplitude-versus-frequency response of the IF circuitry being bell-shaped). As the frequency separation between the two signals increases, or the resolution of the analyzer increases, the individual signal characteristic error becomes less.

2-17. When the CRT displays a group of closely-spaced signals (such as a carrier and its sidebands) with the analyzer set for wide dispersions, the display may appear as a single pip. To examine the group of signals more closely, the operator should first center that portion of the display to be analyzed in greater detail about the graticule f_o vertical line by adjustment of the TUNING control and then set the FREQUENCY DISPERSION switch for a reduced dispersion. Further improvement in

display resolution may be achieved by setting the BANDWIDTH switch to VAR and adjusting the BANDWIDTH VARIABLE control until the best resolution is obtained. The BANDWIDTH VARIABLE control permits continuous adjustment of the IF bandwidth from 1 kHz to 100 kHz. Narrowing of the IF bandwidth (for a given scanning velocity) improves display resolution. Further reduction of the IF bandwidth beyond the point of optimum resolution causes a severe reduction in amplitude display for CW or narrowband signals due to the limited response of the IF amplifiers.

Note

When the BANDWIDTH switch is set to AUTO and the SWEEP switch is set to 10 MS/DIV, the proper IF bandwidth for optimum resolution of CW or narrowband signals is automatically selected by the setting of the FREQUENCY DISPERSION switch.

2-18. Another way to obtain better resolution is to increase the sweep time (i.e., rotate the SWEEP switch counterclockwise). The selection of the appropriate sweep time is determined by the nature of the signal being studied. For example, when the applied signal under analysis is sporadic, it is desirable to operate at short sweep times to increase the probability of intercepting the signal. When examining pulse spectra, reducing the sweep time will reduce the number of pulse lines per scan if the PRF of the applied pulse is less than the IF bandwidth of the analyzer. However, when the PRF of the applied signal is greater than the IF bandwidth of the analyzer, the number of lines is constant regardless of the sweep time (spectral line case).

2-19. To increase the resolution capability by reduction of the frequency dispersion, narrowing the IF bandwidth and increasing the sweep time, the following procedure should be used.

a. Set the BANDWIDTH switch to VAR and rotate the BANDWIDTH VARIABLE control fully clockwise (IF bandwidth = 100 kHz).

b. Adjust the TUNING control so that the desired band of signals appears centered on the screen.

c. Rotate the FREQUENCY DISPERSION switch counterclockwise to spread the band of signals across the screen.

d. Rotate the BANDWIDTH VARIABLE control counterclockwise until the individual signal components are clearly resolved. If proper (optimum) resolution cannot be achieved, rotate the BANDWIDTH VARIABLE control fully clockwise, reduce the dispersion one step, set the SWEEP switch to the next slower sweep time and repeat step d.

2-20. When analyzing pulsed RF signals, it is often more desirable to view the envelope of the pulse spectrum rather than the individual spectral lines. If individual spectral lines are displayed, increase the IF bandwidth by rotating the BANDWIDTH switch clockwise until only the envelope is displayed. To examine the envelope of noise, set the BANDWIDTH switch to 100 kHz and rotate the BANDWIDTH VARIABLE (video filter) control counterclockwise until only the noise envelope is displayed.

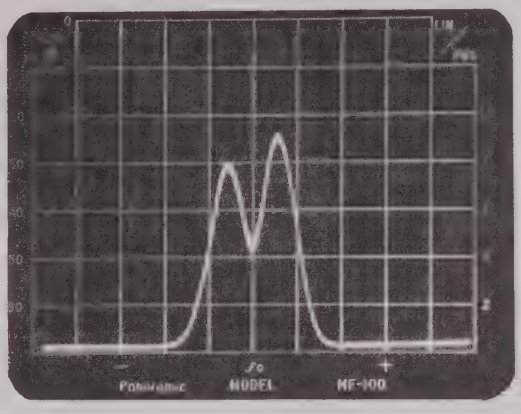
2-21. DETERMINING SPECTRAL COMPONENT FREQUENCIES. The frequency of the spectral component appearing at the graticule f_0 vertical line is indicated on the selected range scale by the tuning pointer. To determine the frequency of a spectral component appearing on either side of the f_0 line, rotate the FREQUENCY DISPERSION VARIABLE control fully clockwise to CAL and note the number of divisions that the spectral component under consideration is from the f_0 vertical line. Note also the calibrated dispersion in kHz/division or MHz/division. The frequency of the spectral component is equal to the tuning dial indication plus (if the spectral component is to the right of the graticule f_0 vertical line) or minus (if to the left) the product of the selected frequency dispersion and horizontal displacement from the f_0 line. For example, if the tuning dial indication is 2.5 GHz, the dispersion is 30 MHz/division and the spectral component is 2-1/2 divisions to the left of the f_0 line, the spectral component frequency would be 2,500 MHz - 2.5 divisions x 30 MHz/division = (2,500-75) MHz = 2,425 MHz. Another way to determine the frequency would be through the RF markers (frequency dispersions of 1 MHz/division or greater).

2-22. To use the RF markers, simply depress the RF MARKER pushbutton switch; markers will appear at multiples of 400 MHz (depending on the setting of the RANGE switch), as indicated on the right edge of the selected scale. The frequencies at which each RF marker appears are listed in table 2-3.

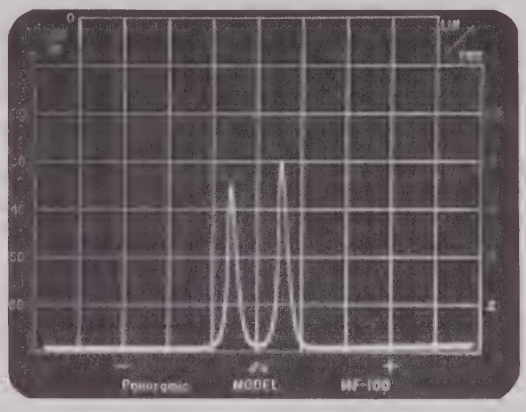
TABLE 2-3. LOCATION OF RF MARKERS

RANGE Switch Setting	RF Marker Frequencies (GHz)
.01 - 3.5 GHz	0*, 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.8, 3.2, 3.6* and 4.0*
3.00 - 6.0 GHz	3.12, 3.52, 3.92, 4.32, 4.72, 5.12, 5.52 and 5.92
4.50 - 10.0 GHz	4.8, 5.6, 6.4, 7.2, 8.0, 8.8 and 9.6
9.00 - 12.4 GHz	9.2, 10.4 and 11.6
12.40 - 15.5 GHz	12.8, 14 and 15.2
15.00 - 21.0 GHz	15.2, 16.8, 18.4 and 20
20.00 - 26.5 GHz	20, 22, 24 and 26
26.50 - 31.0 GHz	27.2 and 29.6
30.00 - 40.0 GHz	30.8, 33.6, 36.4 and 39.2

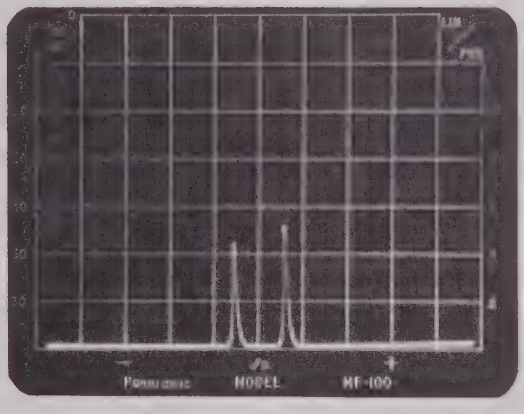
*These three markers are not within the calibrated frequency scale but are represented by small dots.



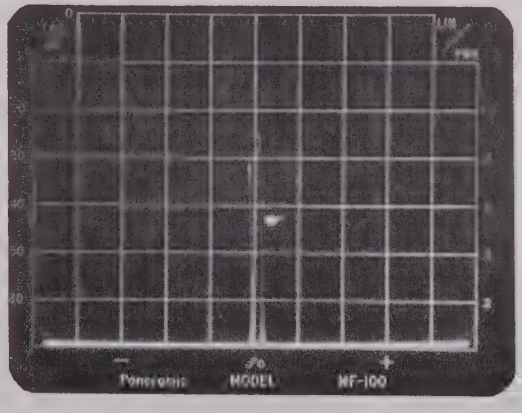
A. Bandwidth Too Broad



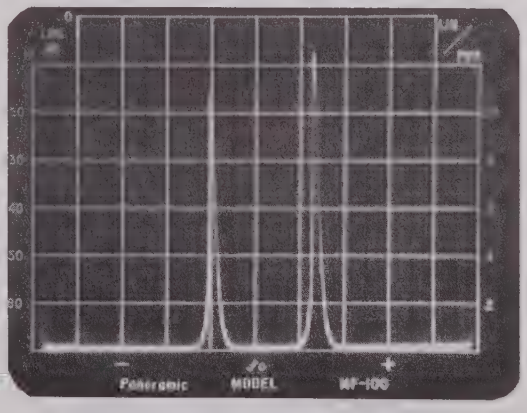
B. Optimum Bandwidth



C. Bandwidth Too Narrow



D. Two CW Signals With Excessive Frequency Dispersion



E. Same CW Signals With Proper Frequency Dispersion

Figure 2-3. Effects of Operating Controls on Display

2-23. PROPER USE OF CRT AMPLITUDE SCALES. The proper use of the LOG, LIN and PWR amplitude scales is detailed in paragraphs 2-24 through 2-26, respectively.

2-24. LOG Scale. Proper use of the 60 dB LOG scale requires that the dynamic range be equal to or greater than 60 dB. The dynamic range is limited at the low end by equipment sensitivity and at the high end by over-driving of the first mixer (typically at input levels in excess of -15 dBm). To obtain the greatest upper limit capability, there must be a minimum of losses in the IF chain: the IF ATTENUATOR switches must be set to 00 DB. The lower limit, sensitivity, is determined by the setting of the BANDWIDTH switch and the IF GAIN control. Since the sensitivity is related to the IF bandwidth, it is recommended that the optimum bandwidth be employed (refer to paragraph 2-16) and the IF GAIN control be adjusted to obtain a noise display one division high. Note that, although a 60 dB dynamic range is achieved, spurious responses may be generated (refer to paragraphs 2-44 through 2-46).

2-25. LIN Scale. The LIN scale should be employed when it is desired to measure the amplitude difference between signals within 20 dB of each other. Note that when switching between LOG, LIN and PWR scales, the position of the trace baseline may shift vertically; the V POS screwdriver control should be adjusted to return the baseline to the lowest horizontal graticule line after scale switching has been accomplished. Should the display amplitude exceed the calibrated region of the graticule, employ the IF ATTENUATOR switches to return the display to within the calibrated area.

2-26. PWR Scale. The PWR scale is employed whenever the amplitude difference between two displayed signals is small. The PWR scale, which is square-law in nature, exaggerates small amplitude differences. As in the case with the LIN scale, the shift in baseline position should be corrected by adjustment of the V POS screwdriver control and the IF ATTENUATOR switches should be set to maintain a display within the calibrated area of the graticule.

2-27. PHASE LOCKING. When the SPA-3000 is operated at dispersions of 300 kHz/division or less, the first local oscillator is not swept; sweeping is accomplished at the third mixer (160 to 60 MHz conversion) stage within the Main Frame. The inherent frequency drift and incidental FM of an unstabilized first local oscillator would not provide resolutions of 1 kHz at any frequency within the equipment range. The incidental FM of the first local oscillator is virtually eliminated by means of a self-contained frequency stabilization circuit that is continuously tunable, thereby permitting phase locking at any frequency.

2-28. To obtain a stable display at dispersions of 300 kHz/division or less, proceed as directed below.

a. Center the signal on the graticule by adjusting the TUNING control and then depress the PHASE LOCK (TO 300 kHz/DIV) pushbutton switch.

b. Carefully rotate the PHASE LOCK ADJUST control throughout its range until the PHASE LOCK ADJUST indicator illuminates. When this occurs, the first local oscillator is stabilized. Center the display on the graticule by means of the PHASE LOCK ADJUST control. Note that if the SPA-3000 is to be tuned to another frequency, the PHASE LOCK (TO 300 kHz/DIV) pushbutton switch should first be released.

2-29. INPUT SIGNAL CLASSIFICATION.

2-30. In general, signals applied to the spectrum analyzer may be divided into two types; discrete and non-discrete. Discrete signals are in the form of periodic waveforms having frequency components which do not vary appreciably with time. The internally generated markers are typical of such signals. Although the marker output consists of harmonically related components, each frequency is discernible as a separate marker pip on the display, provided that the resolution is proper for the frequency spacing of the markers. In practice, discrete signals are typical of periodic oscillation such as modulated or unmodulated signal generators or oscillator outputs.

2-31. Non-discrete signals are typified by random noise, and the frequency distribution of energy is spread out over a broad band of the spectrum rather than consisting of line spectra. Non-discrete signals are displayed on the spectrum analyzer as a varying envelope of amplitude at each spectrum sample. The three amplitude scales (LOG, LIN and PWR) are equally valid for both random and discrete signals. It should be noted that discrete signal levels should be compared only to other discrete signal levels when relative signal strengths are to be determined and random signal levels compared to other random signal levels.

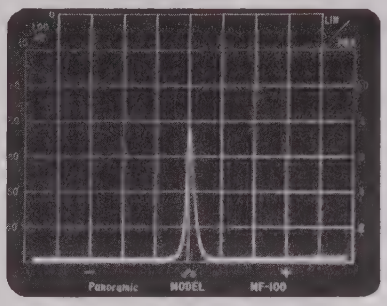
2-32. INTERPRETATION OF SCREEN PRESENTATIONS.

2-33. With a little experience in the operation of a spectrum analyzer, the user will be able to readily recognize the character of the type of signal being displayed.

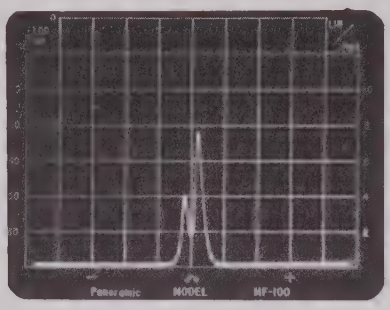
a. A cw signal (see figure 2-4a) appears as a deflection of fixed amplitude with the width of the presentation depending on the selected frequency dispersion, IF bandwidth and sweep time. If the scanning velocity is not too fast, the display will be the frequency response of the IF amplifier. Deviations from a true cw signal can be recognized as follows:

(1) Oscillator drift - display moves slowly across the screen.

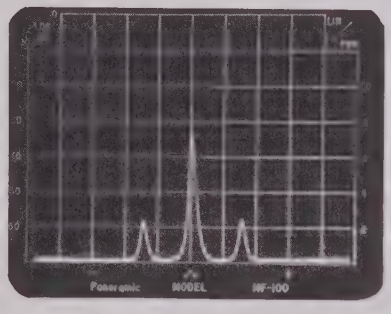
(2) Periodic drift - display moves back and forth across the screen.



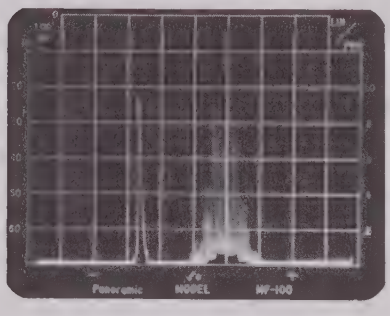
A. CW Signal



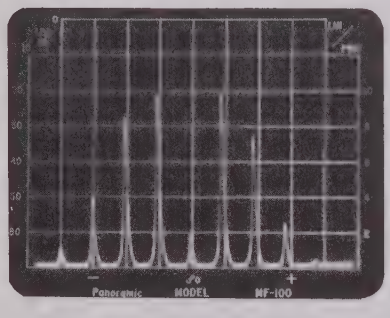
B. Two Interfering Carriers at Optimum Resolution



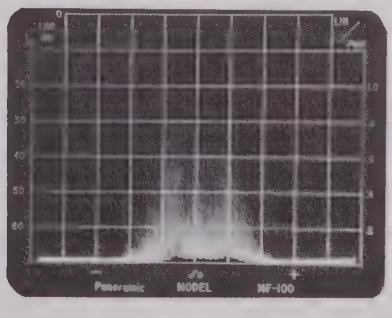
C. Single Tone Amplitude Modulated Signal



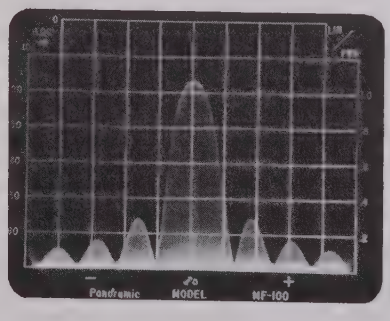
D. Single-sideband Signal Without Suppressed Carrier



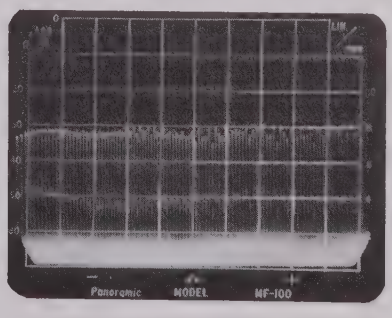
E. Frequency Modulated Signal



F. Typical Sideband Energy of Speech Modulated FM Signal (Slow Sweep Used to Display Envelope Averages)



G. Pulsed RF Signal



H. Impulse Generator Output

Figure 2-4. Typical CRT Presentations of Discrete Signals

(3) Squegging (interruption of an oscillator at an audio or video rate) - display will resemble that of a pulse modulated signal and sideband components will be present in lobes on either side of the signal.

(4) Incidental fm - carrier pip appears to jitter on the display.

b. Two cw signals which are so close in frequency as to cause aural interference (beats) may appear as a single signal whose amplitude varies at a cyclic rate. Further separation will cause a dip at the apex of the display. By improving the resolution, the two signals will gradually separate and become readily identified. (See figure 2-4b.)

c. An amplitude-modulated carrier appears as a deflection of varying amplitude when the modulating frequency is very low. Non-constant tone modulation of low frequency will produce a series of convolutions varying in amplitude along the sides of the carrier pip. As the modulation frequency increases, convolutions move away from the deflection and sidebands become visible. (See figure 2-4c.) It becomes possible to identify the sidebands by reducing the dispersion and increasing the resolution.

d. The appearance of single-sideband signals depends on the type of modulation employed. Tone-modulated single-sideband signals appear as a carrier (for a single tone) or a series of carriers (for multi-tones) of slightly different frequency. Voice or music modulated single-sideband signals appear as a smear of rapidly varying signals which occupy a finite bandwidth. Figure 2-4d illustrates an amplitude-modulated single-sideband signal without carrier suppression.

e. Frequency-modulated carriers appear as a series of vertical deflections as illustrated in figure 2-4e. The spectral lines are spaced at multiples of the modulating frequency. A carrier that is frequency-modulated at a low rate appears as a carrier that wobbles sideways. The vertical deflections shift rapidly when the carrier is modulated by voice or music, as illustrated in figure 2-4f.

f. A pulse-modulated signal (see figure 2-4g) will consist of a series of vertical spikes. The number of spikes is dependent on the pulse repetition rate, the IF bandwidth and the sweep time. The amplitude of each spike represents the energy present at the particular frequency during one of the pulses. The peak envelope of all the spikes represents the energy distribution pattern of the signal.

g. An impulse generator produces a train of very narrow pulses at a relatively low prf. The spectrum, which is essentially an exaggerated pulsed RF display, consists of an extremely broad and quite flat central lobe with very closely spaced spectral lines. (See figure 2-4h.)

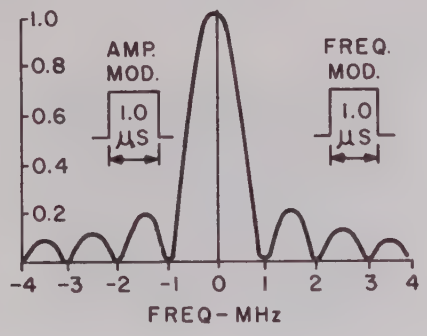
h. Radio frequency interference signals of various types may appear on the screen of the spectrum analyzer. Such signals may have either broad or narrow spectral distributions, depending on the type of interference, and may occur at constant or random repetition rates. Signals which occur at a variable repetition rate (such as those produced by accelerating motors, vibrators, buzzers, etc.) may move in either direction along the frequency axis; this is caused by the fact that the spectrum analyzer is sweeping at a fixed rate whereas the observed signal occurs at a variable rate. These pips will be stationary on the screen when there is synchronization between the signal and the sweep. Signals produced by electrical arcing, switching transients, static and other short electrical impulses have broad spectra which may cover the entire frequency range of the spectrum analyzer.

2-34. CHARACTERISTICS OF PULSED RF SIGNALS.

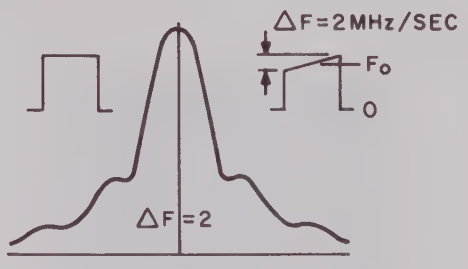
2-35. Since the examination of pulsed RF signals represents an important application for spectrum analyzers, it is well to consider the characteristics of these signals and their appearance on the analyzer display. The pulse that modulates the RF carrier contains as its frequency components the pulse repetition frequency and its harmonics. The pulsed RF signal therefore consists of the carrier frequency and sideband components spaced at the pulse repetition frequency at either side of the carrier. Thus, the greater the pulse repetition frequency, the greater the spacing between adjacent sideband spectral lines. The width of the main lobe is equal to twice the reciprocal of the pulse width ($2/\tau$) while both the width of each of the side lobes and the frequency difference between the carrier and the first null point is equal to the reciprocal of the pulse width ($1/\tau$). Figure 2-5 illustrates typical pulsed RF displays. Figure 2-5a shows a perfect pulsed RF signal; the spectrum is characterized by symmetrical upper and lower sidebands and by the null points reaching the baseline. When the carrier has FM during the time of the pulse, the null points no longer reach the baseline (see figure 2-5b and 2-5c). When there is AM during the time of the pulse, the upper and lower sidebands are lower in amplitude and are spread further apart, as illustrated in figure 2-5d. Figures 2-5e and 2-5f show the effect of simultaneous amplitude and frequency modulation on the spectrum of a pulsed RF signal.

2-36. The actual spectral lines of a repetitive pulse can be observed on an analyzer when the pulse repetition rate is greater than the resolution of the analyzer for the dispersion and sweep rate selected. When spectral lines are to be resolved, a dispersion not exceeding 100 times the prf must be employed to enable adequate visual resolution on a 5-inch CRT. Suitable IF bandwidths and sweep rate settings less than the prf are also required for resolution of the spectral lines. For typical prf's and pulse widths, the actual spectral lines of a pulse are not resolved. In practical RF and microwave pulsed signal analysis, the envelope of the signal is of greatest interest.

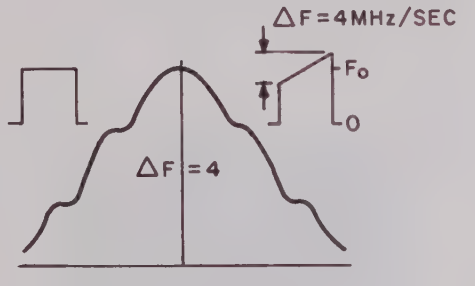
2-37. Figure 2-6 depicts the various displays obtainable of a given pulsed signal as a function of spectrum analyzer parameters. Accurate pulse



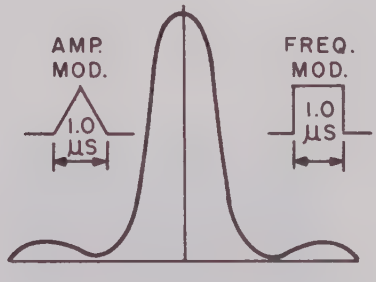
A. Spectrum of a rectangular pulse without AM or FM occurring during pulse. Shape is that of a $\frac{\sin \frac{\omega\tau}{2}}{\frac{\omega\tau}{2}}$ function.



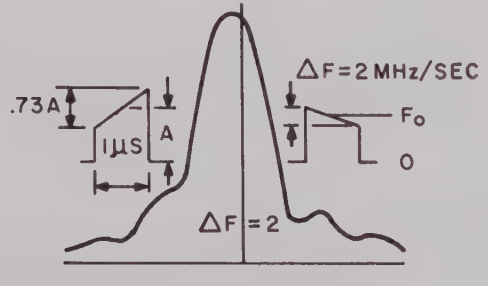
B. Spectrum of a rectangular pulse with linear FM resulting in increased sidelobe amplitude and minimums not reaching zero.



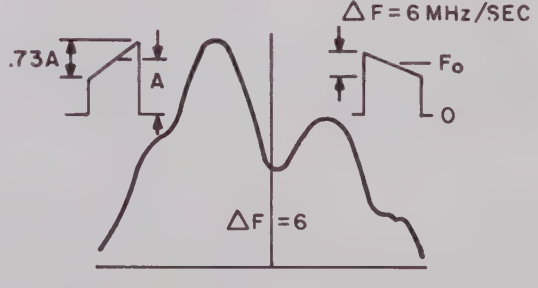
C. Same pulse as B but with more severe FM.



D. Triangular pulse spectrum without FM during pulse. Effective pulse width is shorter than A, causing minimums to occur at wider intervals of frequency and lower sideband amplitudes.

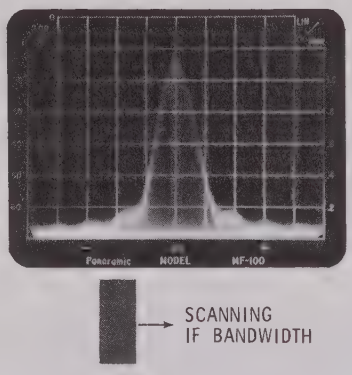


E. Effect of linear AM and FM during pulse. Observe loss in symmetry due to pulse amplitude slope.

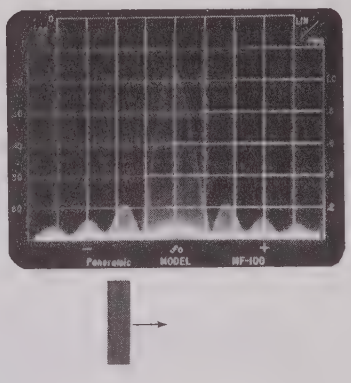


F. More severe case of FM and AM occurring during pulse.

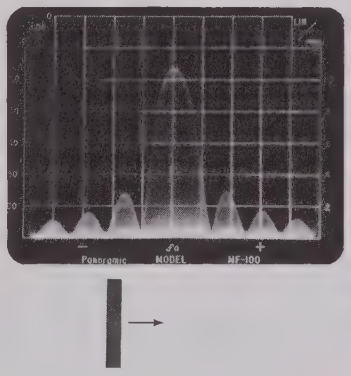
Figure 2-5. Typical Displays of Pulsed RF Signals



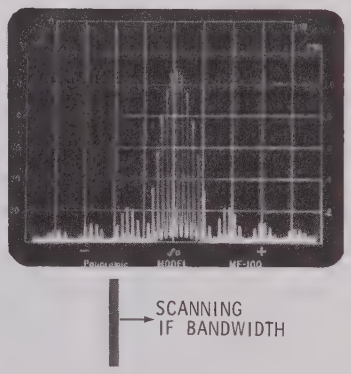
A. Extreme Case ($\Delta f_{IF} \approx 1/\tau$): Extremely wide bandwidth yields minimum information.



B. Inaccurate Envelope Case ($\Delta f_{IF} \approx 0.5/\tau$): Excessive IF bandwidth fails to resolve lobe null points and distorts envelope.



C. Accurate Envelope Case ($\Delta f_{IF} \approx 0.1/\tau$): Moderately narrow bandwidth does not resolve spectral lines but plots spectrum envelope accurately. Moderate prf.



D. Spectral Line Case ($\Delta f_{IF} < f_{prf}$): Very narrow bandwidth resolves spectral lines (within limitations of CRT beam width and visual discrimination). High prf.

Δf_{IF} = analyzer IF bandwidth (Hz)

f_{prf} = input pulse repetition rate (pps)

τ = input pulse duration (seconds)

Figure 2-6. Effect of PRF and Analyzer Bandwidth on Pulsed Signal Analysis

spectrum plotting requires adequate selectivity for precise plotting of lobes and nulls. Excessive IF bandwidths smear and degrade the lobe display, as illustrated in figure 2-6a. A good empirical compromise between adequate selectivity and excessive loss of pulse sensitivity due to the reduction in bandwidth is an IF bandwidth of one-tenth the pulse width (see figure 2-6c). In use the operator sets the bandwidth as broad as possible consistent with an adequately sharp null definition for the lobes. The sweep rate is usually set at less than 1% of the prf to display at least 100 pulses per scan for adequate sectional representation. A stationary spike pattern is readily obtained through the use of external sweep synchronization. Pulse irregularities and missing pulses can be checked conveniently in this manner. Inexperienced users of spectrum analyzers often confuse the spikes due to each pulse with actual spectral lines. A simple test to determine whether spectral lines or pulse spikes are being displayed is to observe the effect that variation of the sweep rate has on the display; if the number of vertical deflections remains unchanged, true spectral lines are being displayed (see figure 2-6d).

2-38. An important factor to be considered in the analysis of narrow pulsed signals is the analyzer's usable pulse sensitivity. Spectrum analyzers are normally rated and specified for cw sensitivity at minimum IF bandwidth. The relationship* between cw and pulse sensitivity is

$$e_{pulse} = \left(\frac{3}{2}\tau\Delta f_{IF}\right) e_{cw}$$

where

e_{pulse} = sensitivity to a pulsed RF signal,

e_{cw} = sensitivity to a cw signal at the same frequency,

τ = pulse width (in seconds), and

f_{IF} = analyzer 3-dB bandwidth (in Hz)

2-39. If for example, a 0.1 microsecond pulse is applied to a spectrum analyzer whose 3-dB bandwidth is 100 kHz, $e_{pulse} = 1.5 \times (0.1 \times 10^{-6}) \times (100 \times 10^{3})\ e_{cw} = 0.015\ e_{cw}$, which corresponds to a 36 dB loss in sensitivity. This loss in sensitivity is due to the fact that the IF bandwidth required for pulse displays ($\approx 0.1/\tau$) is much greater than the IF bandwidth for cw displays, thereby the front end produces a much greater noise background. For a spectrum analyzer with a rated cw sensitivity at 1 kHz bandwidth, there would be an additional 20 dB of background noise when the bandwidth is set to 100 kHz. Thus, for the example given above the total sensitivity difference between the deflection due to the 0.1 microsecond pulse @ 100 kHz IF bandwidth and the cw signal sensitivity @ 1 kHz bandwidth would be 36 + 20 = 56 dB. At a frequency where the cw sensitivity of the spectrum analyzer is -110 dBm and the maximum signal input level for linear operation is -30 dBm, the maximum usable dynamic range for this pulse will be 24 dB [-30 dBm - (-110 dB) - 36 dB -20 dB]. For many applications where the major lobes are of prime interest, the maximum input level can be somewhat greater without significant measurement error. A practical test of adequate freedom from non-linear operation is to check the proportionality of the change in the spectrum display when a small, calibrated amplitude change is introduced. Insertion of 10-dB of attenuation into the input signal path can be used to verify that the analyzer is not being overloaded. The analyzer's sensitivity for pulsed signals can be determined by adding the loss of sensitivity (a positive value) to the cw sensitivity @ 1 kHz bandwidth (see figure 2-7).

* MIT Radiation Laboratory Series, Volume XI, Chapter 7.

2-40. NOISE ANALYSIS.

2-41. In noise analysis (noise being defined as randomly fluctuating signals), the same general techniques are used for setting the equipment for the spectrum of interest as are used for discrete signals. If the input spectrum is broadband, it is very important to monitor the input signal level to prevent equipment overload. The following special techniques should be noted.

a. In general, a fairly wide IF bandwidth is preferred for noise analysis. This permits relatively rapid scans since a wide IF bandwidth gives better noise envelope averaging than does a narrow IF bandwidth. However, if the noise source is highly selective, an IF bandwidth which is narrow compared to the bandwidth of the resonance is required. This permits a detailed presentation of the noise characteristics. When a narrow IF bandwidth is used, a low sweep rate is necessary for correct amplitude presentation.

b. The proper sweep rate can be determined by changing the sweep time slightly and noting whether or not there is any change in the envelope amplitude. (The portion of the envelope having the greatest slope should be examined since the greatest change will occur there.) The sweep rate should be slow enough so that a small change in the sweep rate does not result in an amplitude change. If the sweep rate is at a minimum, the frequency dispersion should be reduced and/or the IF bandwidth increased until it is possible to make a small change in sweep rate without changing the amplitude. Once a sweep which is slow enough to obtain correct results has been established, a slower sweep can be set if improved envelope averaging is required.

c. In noise analysis, video filtering can be used to obtain averaging of the noise spectrum envelope. It is usually desirable to rotate the BANDWIDTH VARIABLE control counterclockwise while the BANDWIDTH switch is in the 1, 3, 10, 30 or 100 kHz position until a single-line presentation is obtained.

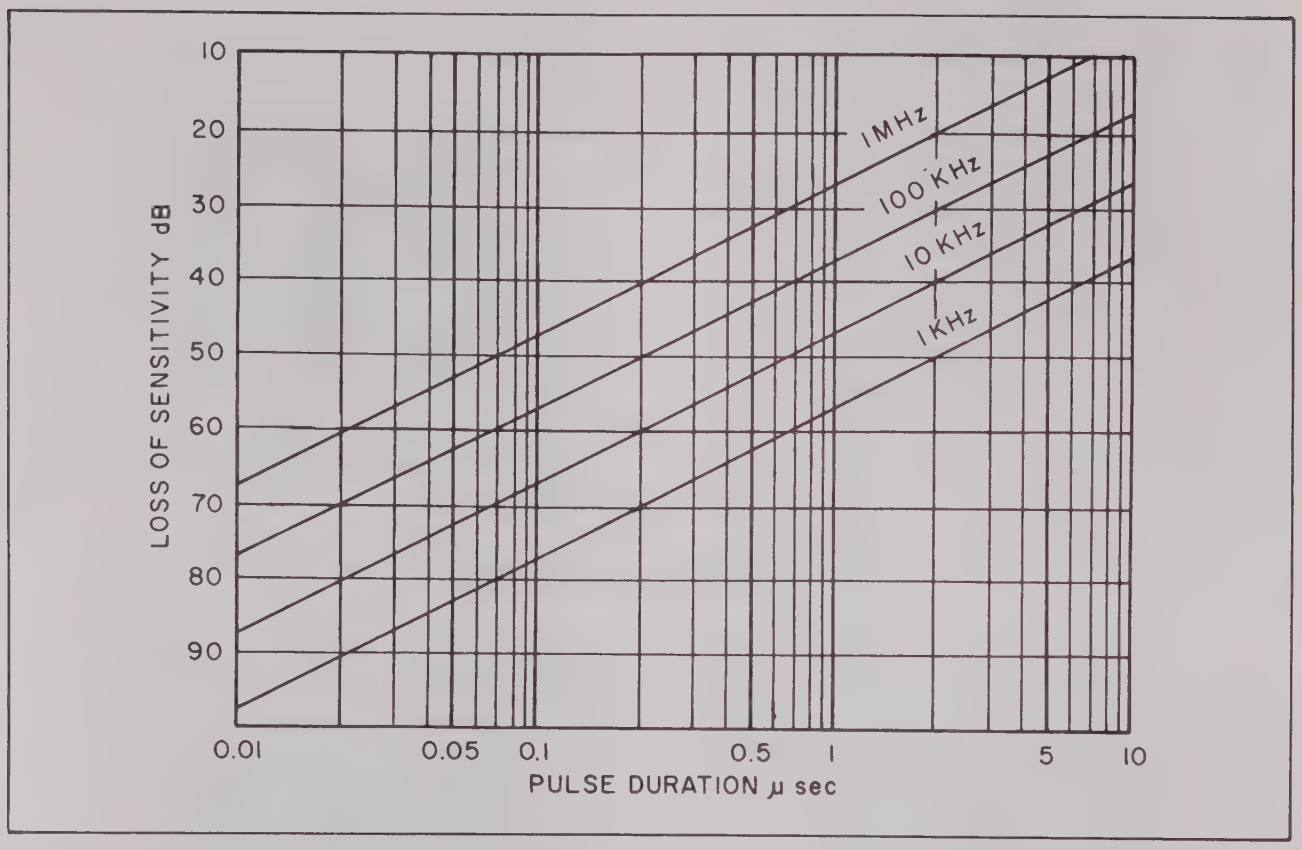


Figure 2-7. Analyzer Sensitivity Correction Due to a Pulsed Signal Compared to a CW Signal at 1 kHz Bandwidth

d. Note that the equipment sensitivity specification in Section I is applicable only for discrete signals. If absolute noise amplitude measurements are required, the spectrum analyzer should be calibrated with a noise source of known noise output level. Such a calibration should be made at the same scanning velocity (dispersion divided by sweep time) and IF bandwidth that is used for the signal measurement.

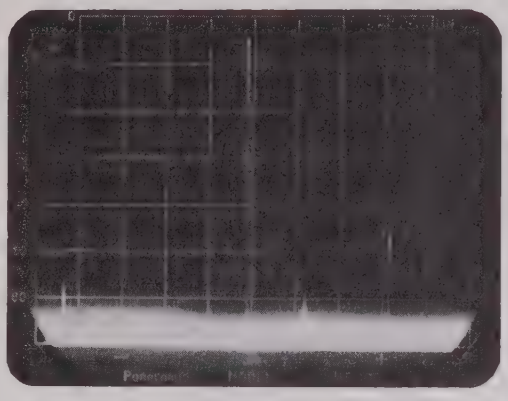
2-42. UNDESIRABLE RESPONSES.

2-43. Because a spectrum analyzer has a broadband input section, undesirable responses may appear on the CRT screen. These responses, and how to recognize them, are described in paragraphs 2-44 through 2-53.

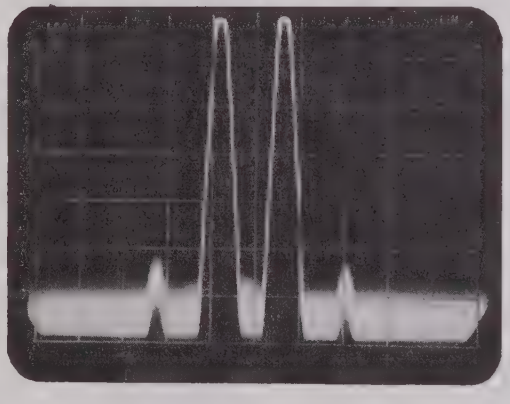
2-44. SPURIOUS RESPONSES. There are two sources of spurious responses generated in any spectrum analyzer; these are (1) intermodulation (IM) products, which are usually generated in the IF section, and (2) first mixer spurious, a form of IM, which is caused by high level signals overdriving the first mixer.

2-45. Two types of IM products may occur - single tone and two tone - both producing spurious responses that are mathematically related to the signal and/or local oscillator frequencies. Single tone IM occurs when a high level signal in the IF mixes with the harmonic of a local oscillator (see figure 2-8a). Two tone IM occurs when two high level signals in the IF encounter a slightly non-linear element (see figure 2-8b). In both cases the IM products are typically greater than 60 dB down when the bandwidth is 10 kHz. Reduction of the bandwidth will also improve the IM products at almost the same rate that the sensitivity is increased, provided that the input signal level is similarly reduced.

2-46. High level signals applied to the first mixer may also generate spurious responses. These are also IM products and are mathematically related to signal and/or local oscillator frequencies. Due to the broad bandwidth of the mixer, the relationship may be very obscure. In either case, spurious responses occur at input signal levels typically greater than -30 dBm. Amplitude non-linearity will not show up until signal levels are greater than -15 dBm; this level is generally specified as the point at which 1 dB compression of the signal occurs. Since the spurious responses are generated by high level signals, reduction of the input signal level and a corresponding improvement in sensitivity will result in a greater spurious-free dynamic range.



a. Single Tone IM Products



b. Two Tone IM products

Figure 2-8. IF Intermodulation (IM) Responses

Figure 2-9 permits the operator to determine the maximum linear dynamic range and maximum spurious-free dynamic range of the analyzer as a function of IF bandwidth. Note that reduction of the IF bandwidth and/or sweep speed improves the dynamic range.

2-47. IN-BAND MULTIPLE RESPONSES (LINEAR OPERATION). The SPA-3000 multiple response analysis charts illustrated in figure 2-10 and 2-11 are plots of input signal frequency versus local oscillator fundamental frequency which satisfy the superheterodyne conversion equation

$$f_s = nf_{LO} \pm f_{IF}$$

where

f_s = input signal frequency (GHz),

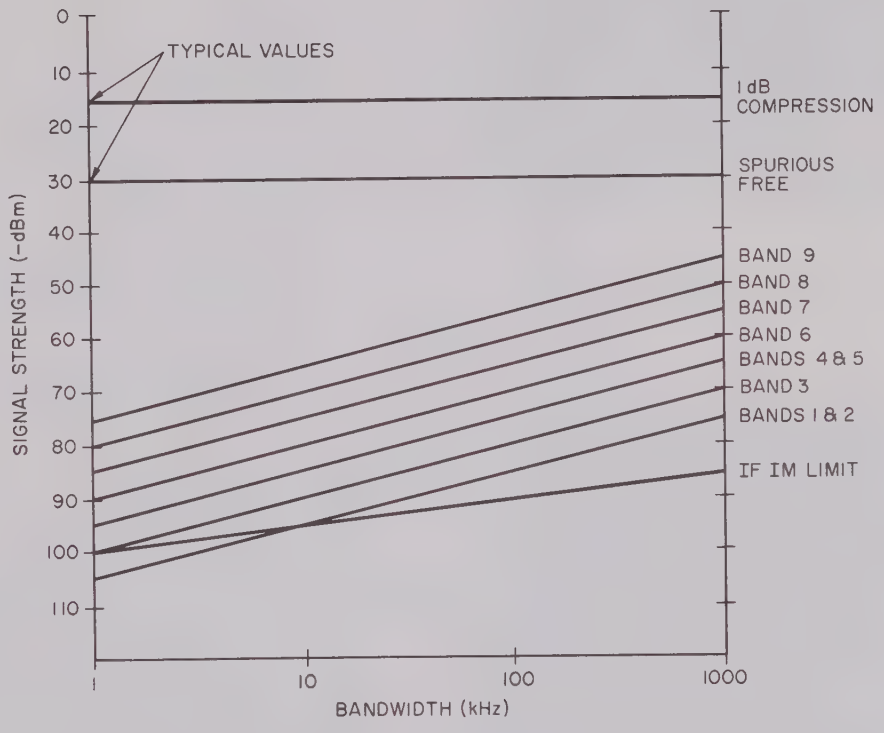
n = local oscillator harmonic employed (fundamental, second harmonic, etc.),

f_{LO} = instantaneous local oscillator fundamental frequency (variable between 4 and 8.08 GHz), and

f_{IF} = first intermediate frequency (4 GHz for bands 1 and 3 through 9, 2.08 GHz for band 2).

2-48. The line marked "1^-" in figure 2-10 represents the range of input signal frequencies versus the local oscillator fundamental frequency that will produce a first IF at 4 GHz. The "1" indicates that the local oscillator harmonic employed in this operating range (band 1) is the fundamental while the superscript "-" signifies that the IF signal is derived by subtracting the input signal frequency from the local oscillator harmonic frequency. Thus, in band 1 (.01-3.5 GHz) operation, a pip representing an applied signal of 2 GHz will appear on the screen when the first LO instantaneous fundamental frequency is 6 GHz. The lines marked "2^-," "3^-," etc., are derived in a similar manner where the first IF of 4 GHz is obtained by subtracting the input signal frequency from the instantaneous first LO second harmonic, third harmonic, etc., frequency, respectively. Note that the SPA-3000 employs only "n^-" mixing modes.

2-49. Because the SPA-3000 was designed to use only the "n^-" mixing modes, the lines marked "1^+," "2^+," etc. represent image responses; i.e., the input signal frequency is equal to the sum of the 4 GHz first IF and the first LO harmonic frequency. For example, if the SPA-3000 is set for band 1 (.01-3.5 GHz) operation and tuned to 2 GHz, application of a 10 GHz signal will cause a pip to appear at the center of the screen. All image responses are twice the IF above the frequency to which the SPA-3000 is tuned. Use of the signal identifier enables the operator to quickly determine if the signal is a true response or an image response as well as the proper band to view the signal.



Example: Determine the maximum dynamic range for both linear and spurious-free operation when the SPA-3000 is tuned to 2.0 GHz and set for a bandwidth of 100 kHz.

a. Draw a vertical line through the 100 kHz point on the bandwidth axis.

b. Note the signal strength where the 100 kHz line crosses the Band 1 line (-85 dBm).

c. The maximum linear dynamic range is the difference between the 1 dB compression point (-15 dBm) and -85 dBm: 70 dB.

d. The maximum spurious-free dynamic range of the first mixer is the difference between the maximum spurious-free operating point (-30 dBm) and -85 dBm: 55 dB.

e. Note the signal strength where the 100 kHz line crosses the IF IM LIMIT line (-90 dBm).

f. The maximum spurious-free dynamic range of the IF circuitry is the difference between the maximum spurious-free operating point (-30 dBm) and the IF IM limit (-90 dBm) determined in step e: 60 dB.

g. The maximum spurious-free dynamic range is the lesser of d or f; in this case 55 dB.

Figure 2-9. Maximum Linear and Spurious-free Dynamic Ranges as a Function of Bandwidth

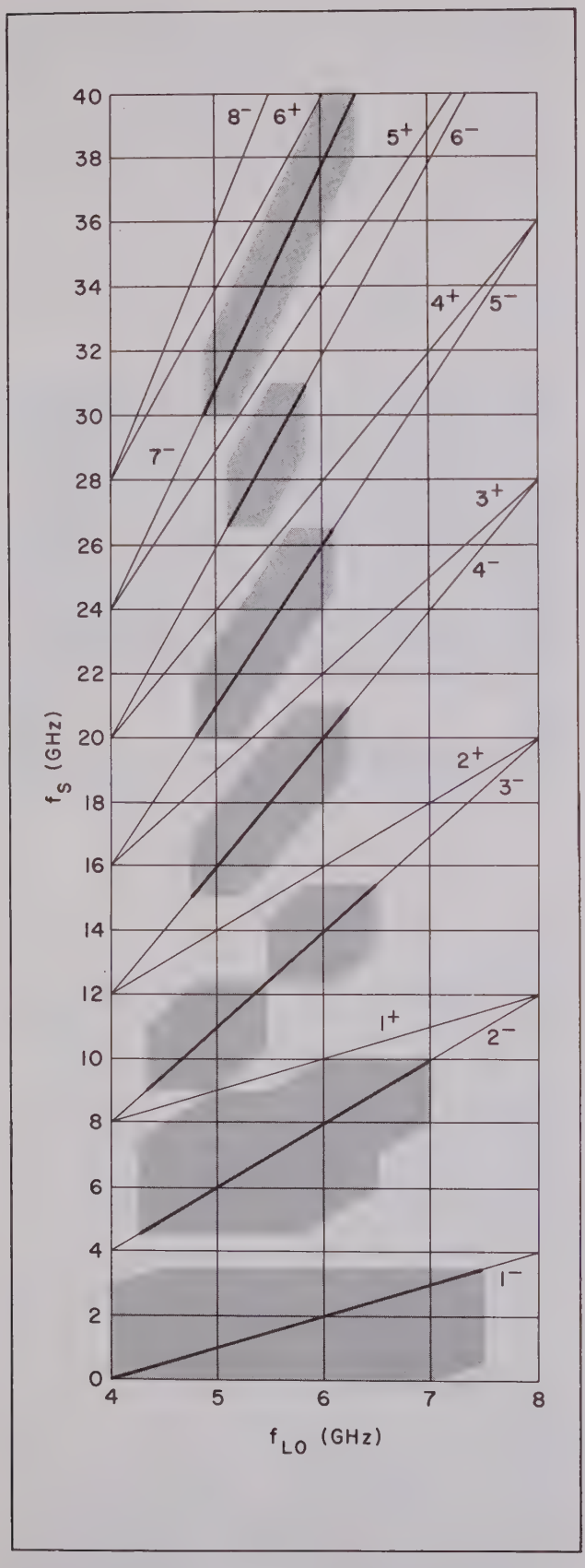


Figure 2-10. Multiple Response Analysis - 4 GHz IF

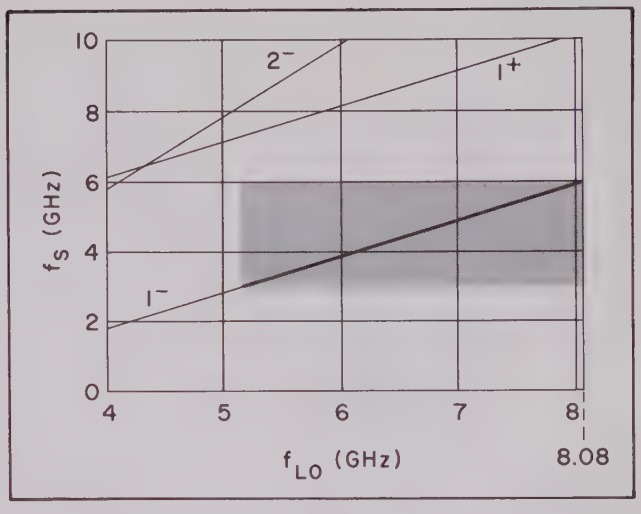


Figure 2-11. Multiple Response Analysis - 2.08 GHz IF

2-50. The shaded areas about each "n⁻" line represent the range of in-band signals that will appear, without the presence of any multiple responses, as a function of first local oscillator frequency and dispersion. The derivation of the shaded area about the "2⁻" line of figure 2-10 is provided below:

For band 3 (4.5 to 10 GHz) operation, the second harmonic of the swept first LO is employed. A maximum dispersion (3 GHz) in-band display at the low end of the band will therefore be obtained when the frequency dispersion switches are set for 300 MHz/division and the TUNING control is adjusted to obtain a pointer indication of 6 on the SIGNAL FREQUENCY GHz scale. This corresponds to a swept first LO center frequency of 5 GHz and sweeping 0.75 GHz. Rectangle A (see figure 2-12), having its center on the "2⁻" line at the point f_{LO} = 5 GHz, f_S = 6 GHz, whose width is 1.5 GHz and height is 3 GHz, defines the range of input signal frequencies that are free from in-band multiple responses for this operating point.

As the TUNING control is rotated clockwise, the center of the rectangle moves up the "2⁻" line, describing the shaded area. When the center of the rectangle reaches the point f_{LO} = 5.75 GHz, f_S = 7.5 GHz (rectangle B), its upper left corner intercepts the "1⁺" line. If, at this operating point, a 9 GHz signal is applied to the SPA-3000, two pips will appear on the display: the first, at the extreme left graticule vertical line, represents an in-band multiple response while the second, at the extreme right graticule vertical line, represents the 9 GHz signal.

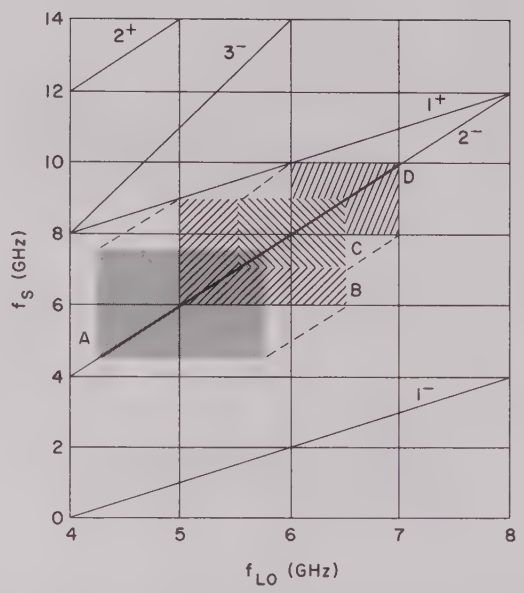


Figure 2-12. Derivation of Multiple Response Chart

Reduction of the dispersion to 2 GHz and tuning to 8 GHz (rectangle C) no longer causes interception of the "1^+" line and the 9 GHz signal will now appear at the extreme right graticule vertical line. Further clockwise rotation of the TUNING control causes the center of the rectangle to continue up the "2^-" line until the point f_{LO} = 6.5 GHz, f_S = 9 GHz (rectangle D) is reached, the operating point for an in-band multiple response-free display of maximum dispersion at the high end of band 3.

2-51. From the foregoing analysis and the fact that the SPA-3000 does not employ the full first LO fundamental frequency range for each tuning band (see figures 2-10 and 2-11), in-band multiple response-free displays of 3 GHz dispersion are obtained below 9 GHz and at least 2 GHz dispersion from 9 to 40 GHz.

2-52. For wide dispersion signal analysis around 4 GHz, there is a problem of IF feedthrough. The signal, in addition to heterodyning in the first mixer, goes directly into the first IF amplifier, causing the entire display base line to rise. To prevent this, an auxiliary first IF at 2.08 GHz is provided to maintain the wide dispersion capability of 3 GHz without in-band multiple responses (see figure 2-11) or images.

2-53. OUT-OF-BAND MULTIPLE RESPONSES (LINEAR OPERATION). Figures 2-10 and 2-11 show that, with only one in-band signal applied, only one signal will be displayed on the CRT. If a signal is applied whose frequency is not within the band being displayed, it might appear on the CRT due to harmonic mixing within the first mixer. Displaying the frequency range of 0.2 to 3.2 GHz (RANGE switch set to .01-3.5 GHz, TUNING control set for dial indication of 1.7 GHz and dispersion controls set for 300 MHz/division) and applying the output of a frequency multiplier (operating at 1.55 GHz and peaked for maximum output of the fourth harmonic) produces the display shown in figure 2-13. The

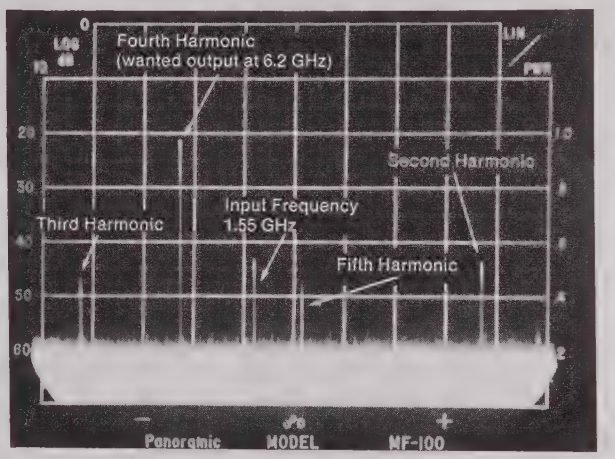


Figure 2-13. Typical Display Showing Out-of-Band Multiple Responses

fundamental and second harmonic outputs of the multiplier are true responses while the pips indicative of the third, fourth and fifth harmonics are multiple responses caused by out-of-band signals mixing with the second harmonic of the swept first local oscillator. Setting the RANGE switch to band 3 (4.5-10 GHz) and readjusting the TUNING control for a center frequency of 6.2 GHz would eliminate all but the desired fourth harmonic and fundamental output of the multiplier from appearing on the screen. Four optional accessory filters will eliminate all out-of-band multiple responses and IF feedthrough up to 10 GHz: these are listed below.

a. 3 GHz low-pass filter (band 1, 0.01-3.5 GHz).

b. 3 to 6 GHz band-pass filter (band 2, 3-6 GHz).

c. 6 to 8 and 8-10 GHz band-pass filters (band 3, 4.5-10 GHz).

2-54. APPLICATIONS.

2-55. AM MEASUREMENTS. The amplitude vs. frequency display of the analyzer is useful in determining the percentage modulation of applied amplitude-modulated signals. The percentage modulation can be determined by using the LIN scale and

adjusting the carrier pip amplitude for a full scale display (1 on the LIN scale). Once this has been accomplished, note the relative amplitude of one sideband with respect to the carrier. The percentage modulation is equal to twice the relative amplitude of the sideband to the carrier. Thus, if the carrier amplitude is five divisions high (1.0 on the LIN scale) and the sideband amplitude is one division high (0.2 on the LIN scale), the percentage modulation is equal to 2 x 0.2/1 = 40%.

2-56. FM MEASUREMENTS. The deviation and modulation index of frequency modulated signals can be readily deduced from the relative levels of the carrier and sidebands using the Bessel function coefficients of the series expansion for an f-m signal (see Panoramic Analyzer, Volume 1, No. 4 for FM measurement techniques). Deviations of transmitters and signal generators are frequently measured by varying the modulation frequency until the first carrier null is obtained. The deviation is then obtained by multiplying this modulating frequency by 2.4. This is the most accurate practical method of measuring deviation and actual band occupancy of the sidebands. This dynamic analysis also has the advantage of the revelation of second order effects (such as residual AM) which causes assymmetry of the sidebands. To determine the deviation of an FM signal generator or transmitter, proceed as follows.

a. Couple the spectrum analyzer to the signal generator or transmitter under test. Be sure that the maximum input level to the analyzer is not exceeded.

b. With the signal generator or transmitter unmodulated, tune the spectrum analyzer to center the carrier frequency on the screen.

c. Couple a source of modulation to the signal generator or transmitter; set the modulator to a suitable frequency and minimum output level. Note that the modulation frequency should be greater than the selected analyzer bandwidth.

d. Slowly increase the modulator output amplitude until the carrier amplitude decreases to its first null. (It may be necessary to remove inserted IF attenuation and/or increase the IF GAIN control setting to provide maximum sensitivity when observing the first carrier null.) When the first carrier null is attained, the modulation index is 2.4 and the deviation is 2.4 times the frequency of the modulating frequency. Higher order carrier nulls and/or sideband nulls can be evaluated using Bessel tables.

2-57. PULSE ANALYSIS. The characteristics of pulsed RF signals can be analyzed and the pulse width measured from the amplitude versus frequency display presented during spectrum analyzer operation. Many of the pulse characteristics can be verified by converting the analyzer to a synchroscope by setting the SWEEP switch and SWEEP SYNC switch to the appropriate red settings. The pulse width, incidental am and pulse repetition rate can then be measured directly from the synchroscope display. (See figure 2-14.) To obtain a synchroscope (time domain) display of the pulsed RF signal, first obtain a convenient spectrum analyzer display and then continue as directed below.

a. Adjust the TUNING control so that the peak of the main lobe is coincident with the graticule f_o vertical line.

b. Ascertain that the MARKER MODULATION switch is set to OFF and that the MARKER LEVEL control is rotated fully counterclockwise to OFF.

c. Set the BANDWIDTH switch to the red 1000 kHz position.

d. Depress the 0 pushbutton switch.

e. If the SWEEP is to be synchronized internally by the detected video signal, set the SWEEP/SYNC switch to the red INT SYNC position. If the sweep is to be synchronized by an external pulse, couple the synchronizing pulse between pins D (EXT SYNC INPUT) and M (GRD) of Main Frame rear panel connector J1 and set the SWEEP/SYNC switch to the red EXT SYNC position.

f. Set the SWEEP switch to the desired red uS/DIV position.

Note

Do not adjust the setting of the TUNING control once in synchroscope operation. Slight detuning of the first local oscillator will cause distortion or loss of signal.

2-58. CHECKS OF RADAR SET PERFORMANCE. The spectrum analyzer can be coupled (via directional couplers or an antenna) to a radar set to evaluate its operation.

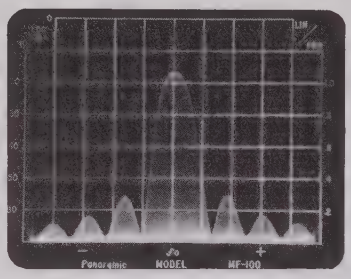
a. The radar output pulse can be observed on the spectrum analyzer to determine pulse width, pulse repetition rate, incidental AM and FM, mode failures and relative sidelobe amplitude and symmetry.

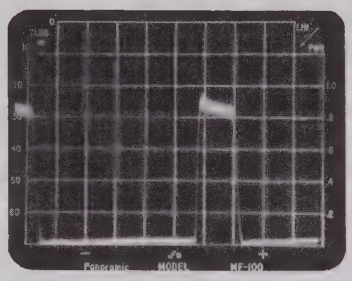
b. The energy distribution in the transmitted pulse can be determined and used as the basis for receiver bandwidth design. Should the receiver bandwidth be too narrow, the pulse shape will not be preserved and the radar accuracy will be compromised. Conversely, increasing the receiver bandwidth beyond the point of optimum energy reception serves no useful purpose and will decrease the signal-to-noise ratio.

c. Receiver afc can be checked by displaying both the magnetron output and the local oscillator frequency simultaneously. Because the magnetron is pulsed, a typical pulsed RF pattern will represent the magnetron output. The receiver local oscillator output, however, will be represented by a single pip displaced from the center of the pulsed pattern by the IF frequency. Any magnetron pulling resulting from antenna rotation should produce a corresponding shift in local oscillator frequency.

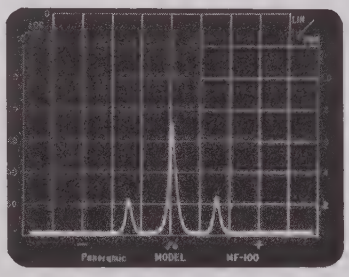
FREQUENCY BASE

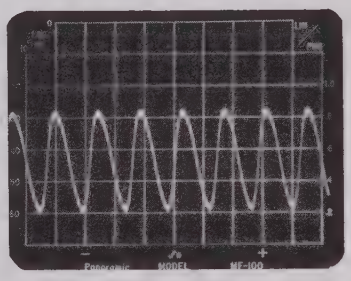
TIME BASE



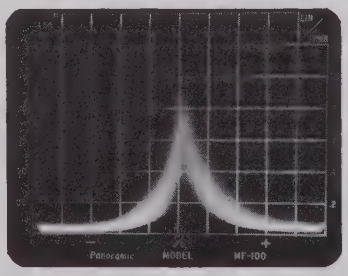


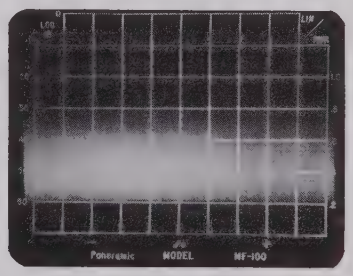
A. Pulse





B. Single Tone Amplitude Modulation





C. Noise

Figure 2-14. Comparison of Frequency-Base and Time-Base Displays

d. TR boxes may be tuned accurately to the magnetron frequency by first tuning the spectrum analyzer so that the magnetron frequency is centered on the display. Then, with the magnetron turned off and an impulse generator applied to the TR box, the spectrum analyzer will display the frequency response characteristics of the TR box and the TR box can then be tuned so that its center frequency is the same as the magnetron.

2-59. ANTENNA PATTERNS. An X-Y plot of antenna patterns can be obtained by using the spectrum analyzer as an RF voltmeter and by having the analyzer sweep synchronized to the antenna rotation.

a. With the analyzer adjusted for a LOG display, couple the antenna under test to the appropriate input connector. The antenna should be installed on a rotating platform and directed toward a transmitting antenna.

b. Tune the spectrum analyzer to the transmitted frequency. Once the analyzer is tuned to the signal, depress the 0 pushbutton switch and adjust the TUNING control to obtain a maximum display amplitude.

c. Set the SWEEP/SYNC switch to SINGLE and set the SWEEP switch to 1000 MS/DIV.

d. Couple an external x-y recorder to the appropriate terminals of Main Frame rear panel connector J1.

e. Rotate the antenna at a speed slightly faster than 6 revolutions per minute so that one complete antenna revolution will be completed within the time for one sweep.

f. When the antenna is directed away from the transmitting antenna, depress the SINGLE pushbutton switch. In this manner the main lobe of the antenna pattern will appear approximately centered on both the CRT and recorder.

2-60. RFI MEASUREMENTS. Spectrum analyzers are extremely useful when used in conjunction with RFI meters to help locate and identify the nature of the signal to be measured by the RFI meter. Except for approximate measurements, a spectrum analyzer cannot replace an RFI meter to determine absolute signal levels. On the other hand, the very narrow window of the RFI meter makes it impractical for locating signals (scanning) and the meter indications of an RFI meter are not as conclusive as a spectrum analyzer display for evaluating the type of signal being measured.

2-61. PACKAGING.

2-62. Figure 2-15 illustrates the method of packaging both the Main Frame and RF-3000 portions of the analyzer for long term storage or shipment. For short term storage, use a suitable protective covering (such as a sheet of paper or plastic) and store the instrument in a clean and dry area. Store accessories and instruction manual in a carton or bag and fasten to the equipment to avoid loss.

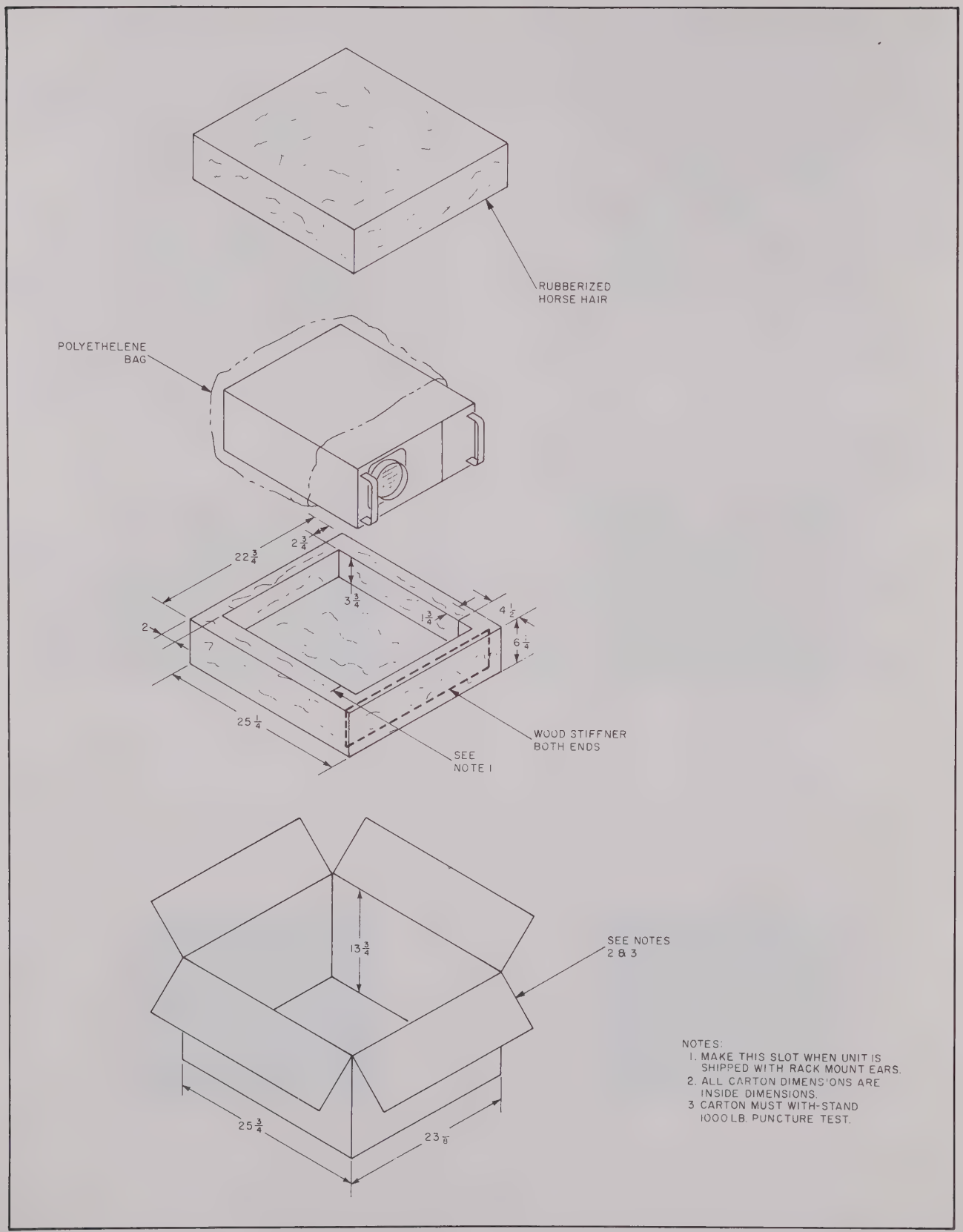


Figure 2-15. Packaging Diagram

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The RF-3000 is a multiband front end that heterodynes either the fundamental or harmonic of a tunable swept first local oscillator with the applied RF signal to produce a first IF centered at either 2.08 or 4 GHz. A second conversion develops a 160 MHz second IF that is coupled to the Main Frame, where further signal processing produces a frequency-amplitude (spectrum analyzer) or time-amplitude (synchroscope) CRT display of the applied signal.

3-3. SIGNAL FLOW ANALYSIS, BAND 1, 3 AND 4 OPERATION. (See Figures 3-1, 5-1 and 5-2.)

3-4. RF STEP ATTENUATOR AT1. Signals within the coaxial cable frequency range coupled to SIGNAL INPUT .01-12.4 GHz jack AT1J1 are applied directly to RF input step attenuator AT1. The attenuation inserted into the applied signal path is adjustable from 0 to 60 dB, in 10 dB steps, by rotation of the RF ATTENUATOR dB switch. The output of the step attenuator is coupled to coaxial relay A1K1, which directs the applied signal to the appropriate coaxial first mixer (refer to paragraphs 3-6 and 3-21).

3-5. SWEPT FIRST LOCAL OSCILLATOR V3. RF energy employed for heterodyning with the applied signal is obtained from voltage-tuned backward wave oscillator (BWO) V3. The output frequency of the BWO, which is tunable from 4 to 8.08 GHz, is determined by the instantaneous helix-to-cathode voltage (refer to paragraph 3-34). The primary output used for mixing is taken from port B and is coupled through 8 GHz low-pass filter A1FL1 to coaxial relay A1K3, the latter routing the signal to the appropriate first mixer (refer to paragraphs 3-6, 3-21 and 3-25). A secondary output from port A is coupled to coaxial relay A1K5, which routes the signal to either the phase lock circuitry (refer to paragraph 3-49) or the marker circuitry (refer to paragraph 3-61).

3-6. RADIAL LINE MIXER A1A4. When RANGE switch S10 is set to .01-3.5 GHZ, 4.5-10 GHZ or 9-12.4 GHZ (band 1, 3 or 4, respectively), coaxial relay A1K1 is in its unenergized state and the output of RF step attenuator AT1 is applied directly to the input (J1) of radial line mixer A1A4. RF energy from port B of swept first local oscillator V3 is simultaneously applied to A1A4J2 via 8 GHz low-pass filter A1FL1, unenergized coaxial relays A1K3 and A1K2, 4 GHz notch filter A1FL2 (refer to paragraph 3-10), frequency selective T A1CP2 and 3 dB pad A1AT2. The frequency selective T, in conjunction with 50 ohm termination A1AT1, ensures that a good impedance match is obtained for all applied signal frequencies.

3-7. The input section of the radial line mixer is a T whose arms are of unequal characteristic impedance. The arm which receives the local oscillator power is of higher impedance than the arm in which mixer diode A1A4CR1 is installed. Applied signal power, which is coupled to the leg of the T, will therefore divide unequally, most of it going to the mixer diode. The non-linear characteristics of the diode causes the applied signal to heterodyne with the output of the first local oscillator. The rectified crystal current component is returned to ground through A1J1-F, P1-F and a diode load resistor selected by the setting of RANGE switch S10B. Changing load resistance as a function of the harmonic employed in the mixing process establishes the diode operating point for optimum sensitivity. Note that for fundamental mixing (band 1 operation) the load resistance is zero.

3-8. The sum and difference frequencies of the applied signal and both the swept first local oscillator fundamental and harmonic frequencies are loop coupled to the output section of the radial line mixer, a single cavity tuned to 4 GHz.

3-9. When employing dispersions of 1 MHz/division or greater (the first LO being swept across its selected frequency range) or when using dispersions below 300 kHz/division (the first LO being fixed tuned), only those mixer output frequencies in the vicinity of 4 GHz are passed through the cavity to 5 GHz low-pass filter A1FL3 (refer to paragraph 3-12) via unenergized coaxial relay A1K4; all other frequencies are reflected by the cavity.

3-10. 8 GHZ LOW-PASS FILTER A1FL1 AND 4 GHZ NOTCH FILTER A1FL2. The instantaneous output of the swept first local oscillator is not ideal; its spectrum does not consist of only one frequency. Harmonics are present as well as 1/f noise. Although the harmonic levels are typically greater than 20 dB below the fundamental, 8 GHz low-pass filter A1FL1 further attenuates their level. This additional attenuation ensures that the harmonics of the BWO do not reach the mixer, where they might otherwise add to mixer-generated harmonics and cause variations in power levels.

3-11. The 1/f noise about the fundamental output of the BWO would be directly coupled through the radial line mixer when the RF-3000 is tuned to frequencies at the low end of band 1 (i.e., 10 to 20 MHz), causing a degradation of sensitivity at these frequencies. 4 GHz notch filter A1FL2, inserted in the BWO

output path, attenuates the 1/f noise at 4 GHz when the swept LO is operating near 4.01 GHz.

3-12. 5 GHZ LOW-PASS FILTER A1FL3 AND 4 GHZ PRESELECTOR A1FL4. The output of the radial line mixer A1A4 (during band 1, 3 or 4 operation) or any of the three optional external waveguide mixers (during band 5 through 9 operation) is applied to the series combination of 5 GHz low-pass filter A1FL3 and 4 GHz preselector A1FL4. The latter consists of three high-Q aperture-coupled coaxial cavities in series, each cavity being 1/4 wavelength at 4 GHz. The filter and preselector pass only the desired first IF output (4 GHz) of the first mixer to the second mixer (refer to paragraph 3-13). All other outputs of the mixer are greatly attenuated to ensure that spurious responses are not developed by BWO harmonics being coupled to the second mixer or second local oscillator fundamental and/or harmonic power being coupled to the first mixer.

3-13. SECOND MIXER/160 MHZ PREAMPLIFIER A1A1. The 4 GHz IF output of preselector A1FL4 (during all but band 2 operation) is coupled to second mixer A1A1CR1 via the straight section of T A1CP3. Second local oscillator power at 3.84 GHz (refer to paragraph 3-16) is simultaneously applied to the diode via the T leg. The dc crystal current output of the mixer is returned to ground through A1A1L1 and A1A1FL1 while the resultant 160 MHz difference frequency output (second IF) is coupled through unenergized relay A1A1K1 to amplifier A1A1Q1.

3-14. When operating in band 2 (refer to paragraph 3-18), the 2.08 GHz output of A1FL7 is coupled to a duplicate second mixer (A1A1CR2) via the straight section of T A1CP5. Second LO power at 1.92 GHz (refer to paragraph 3-16) is simultaneously applied to the mixer via the T leg. The dc crystal current output of the diode is returned to ground through A1A1L2 and A1A1FL2 while the resultant 160 MHz difference frequency output (second IF) is coupled through relay A1A1K1 (energized by application of -26 volts via S10D-2) to amplifier A1A1Q1.

3-15. 160 MHZ BAND-PASS FILTER/AMPLIFIER A1A2. The output of amplifier A1A1Q1 is then applied to a band-pass filter at the input of A1A2. The narrow pass band of this filter, centered at 160 MHz, provides the frequency selectivity necessary for spurious-free operation. After a stage of amplification, the 160 MHz second IF signal is coupled through the RF-3000 rear panel IF OUTPUT jack and IF patch cable 102-9200-361 to the circuitry within the Main Frame.

3-16. SECOND LOCAL OSCILLATOR A1A3. RF energy employed to obtain the second IF of 160 MHz is developed by second local oscillator A1A3. The oscillator is basically a rectangular cavity with a 1/4 wavelength (at 1.92 GHz) resonant line. The collector of A1A3Q1 is mounted on the line at a point where an optimum impedance match is obtained. Coarse tuning of the oscillator is accomplished by a single tuning screw which effectively varies the length of the line by changing the capacitance at the end of the resonator. Fine tuning is achieved by adjustment of feedback trimmer capacitor A1A3C1. Output power is extracted at the end of the resonant line by two E-field probes: one probe couples the 1.92 GHz output of the oscillator to second mixer A1A1CR2 (refer to paragraph 3-13) while the second probe drives frequency doubler A1A5.

3-17. FREQUENCY DOUBLER A1A5 AND 3.84 GHZ PRESELECTOR A1FL5. The 1.92 GHz output from A1A3J1 is coupled to frequency doubler A1A5, which generates harmonics of the applied signal. The output of this harmonic generator is then applied to 3.84 GHz preselector A1FL5, which attenuates all frequency components other than the 3.84 GHz signal that is then coupled to second mixer A1A1CR1.

3-18. SIGNAL FLOW ANALYSIS, BAND 2 OPERATION. (See Figures 3-2, 5-1 and 5-2.)

3-19. In band 2 (3 to 6 GHz) operation, use of a 4 GHz first IF is not practical, as it would permit direct IF feedthrough of applied signals at 4 GHz to reach the second mixer, causing the entire base line of the display to rise. An auxiliary first IF is therefore employed when operating in this input frequency band.

3-20. T MIXER A1A6. When RANGE switch S10 is set to 3-6 GHz (band 2), -26 volts from S10D-2 energizes coaxial relays A1K2 and A1K3, coupling both the output of step attenuator AT1(refer to paragraph 3-4) and swept first local oscillator V3 (refer to paragraph 3-5) simultaneously to the inputs of T mixer A1A6. The output of the mixer (refer to paragraph 3-7) is coupled through 3 dB pad A1A6AT1 (which acts as a dc crystal current return) to 2 GHz low-pass filter A1FL6.

3-21. 2 GHZ LOW-PASS FILTER A1FL6 AND 2.08 GHZ PRESELECTOR A1FL7. The output of T mixer A1A6 is applied to the series combination of 2 GHz low-pass filter A1FL6 and 2.08 GHz preselector A1FL7. The latter consists of two high-Q aperture-coupled coaxial cavities in series, each cavity being 1/4 wavelength at 2.08 GHz. The filter and preselector pass only the desired first IF output (2.08 GHz) of the first mixer to the second mixer (refer to paragraph 3-13). All other outputs of the mixer are greatly attenuated to ensure that spurious responses are not developed by feedthrough of either first local oscillator power to the second mixer or second local oscillator power to the first mixer.

3-22. SIGNAL FLOW ANALYSIS, BAND 5 THROUGH 9 OPERATION. (See Figures 3-3, 5-1 and 5-2.)

3-23. EXTERNAL WAVEGUIDE MIXERS. Unlike band 1 through 4 operation, where the first frequency conversion takes place in an internal mixer, the waveguide frequency bands of 12.4 to 15.5 GHz, 15 to 21 GHz, 20 to 26.5 GHz, 26.5 to 31 GHz and 30 to 40 GHz require external waveguide input mixers. Three optionally available waveguide

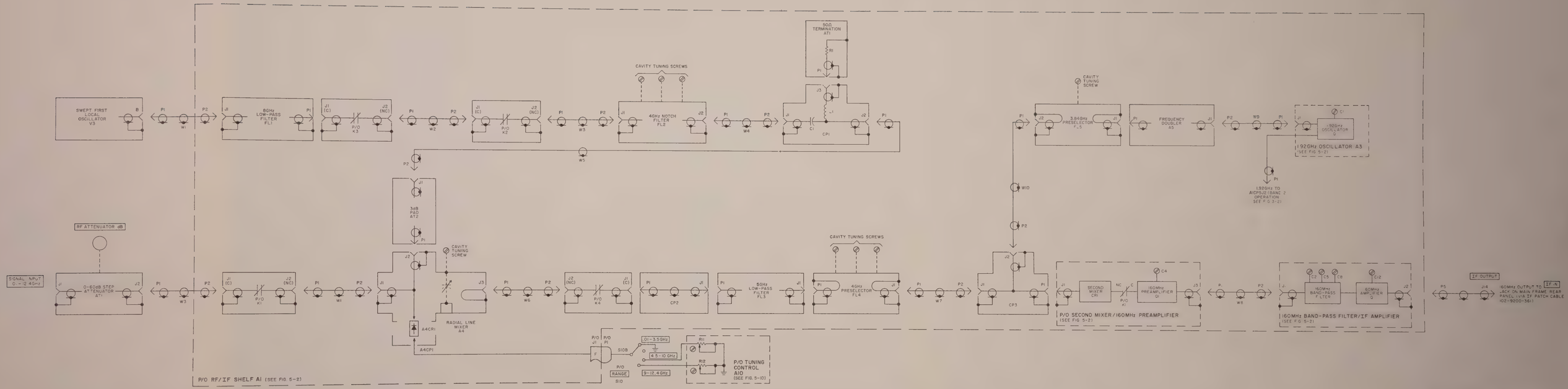


Figure 3-1. Band 1, 3 and 4 Operation, Detailed Block Diagram

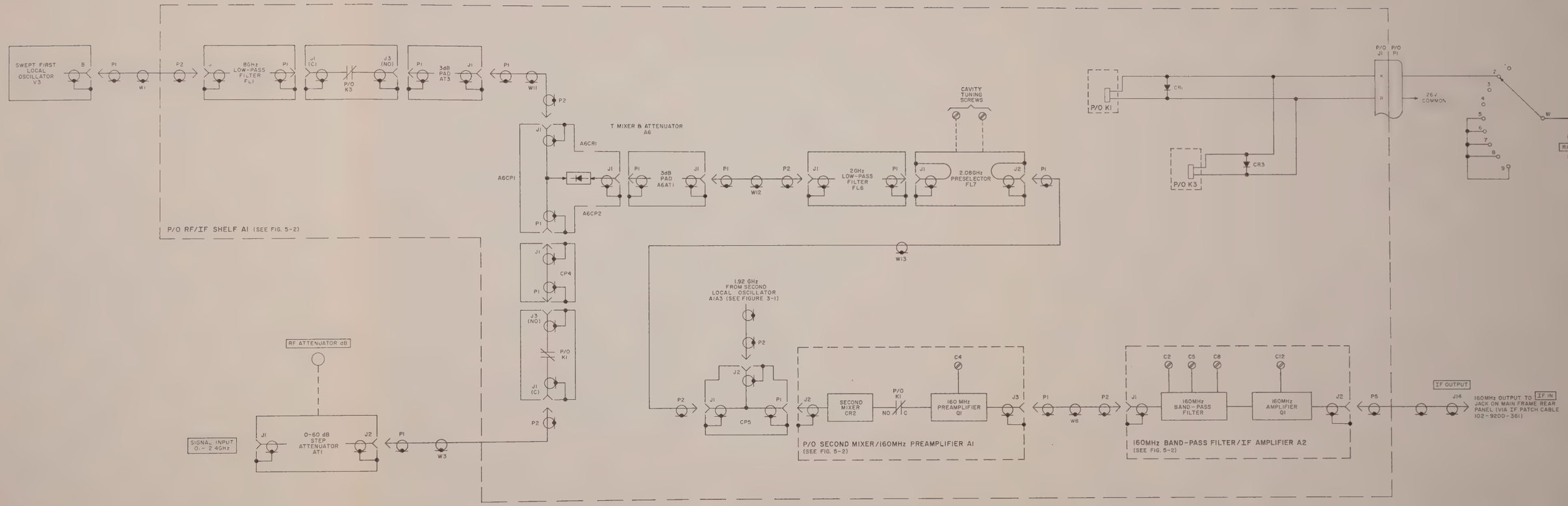


Figure 3-2. Band 2 Operation, Detailed Block Diagram

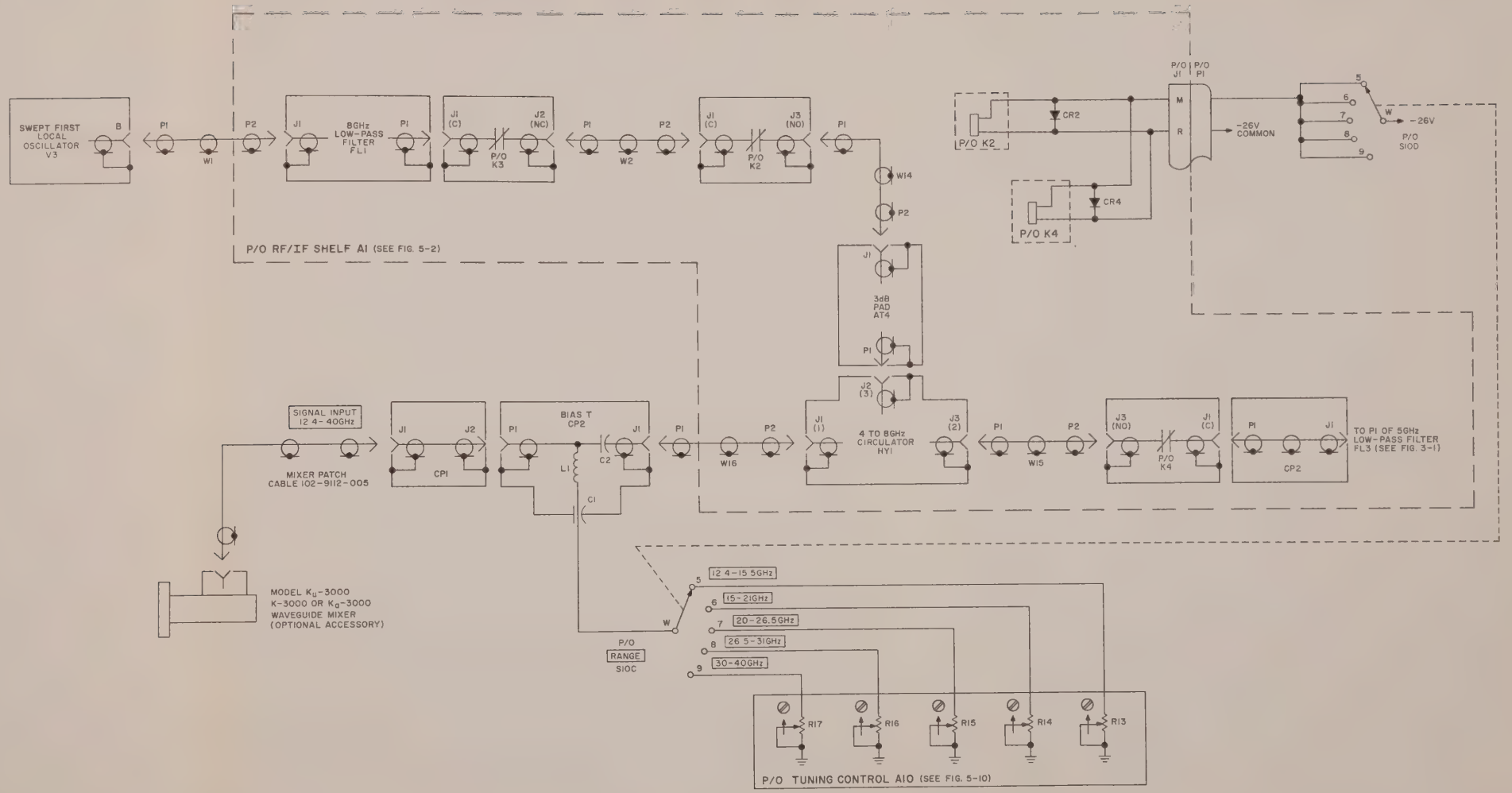


Figure 3-3. Band 5 through 9 Operation, Detailed Block Diagram

mixers cover this input frequency range; the Models K_u-3000 (12.4 to 18 GHz), K-3000 (18 to 26.5 GHz) and K_a-3000 (26.5 to 40 GHz) Waveguide Mixers.

3-24. When RANGE switch S10 is set to any one of the five waveguide frequency bands, -26 volts from S10D-5, 6, 7, 8 or 9 energizes coaxial relays A1K2 and A1K4. Energization of A1K2 couples the BWO output (refer to paragraph 3-5) from 8 GHz low-pass filter A1FL1 (refer to paragraph 3-10) and unenergized coaxial relay A1K3 to the coaxial connector of the external waveguide mixer (coupled to SIGNAL INPUT 12.4-40 GHZ jack CP1J1 via mixer patch cable 102-9112-005) through 3 dB pad A1AT4, 4 to 8 GHz circulator A1HY1, and bias T CP2. The RF signal to be analyzed is coupled to the waveguide input of the mixer.

3-25. The outputs of the external mixer (refer to paragraph 3-7) are coupled back to the RF-3000 via the patch cable and CP1. The crystal current component is routed through the T leg of CP2 and S10C to the appropriate adjustable load resistor that establishes the proper diode operating point for optimum sensitivity during harmonic mixing. All other outputs of the external mixer are coupled through the straight section of CP2, circulator A1HY1, energized coaxial relay A1K4 and coupler A1CP2 to 5 GHz low-pass filter A1FL3 (refer to paragraph 3-12).

3-26. TUNING AND DISPERSION CONTROL CIRCUITRY. (See Figures 3-4 and 5-1.)

3-27. CENTER FREQUENCY TUNING. The center frequency of BWO V3 is determined by its quiescent helix-to-cathode voltage. TUNING control R5, a 10-turn precision potentiometer, in conjunction with differential amplifier A10Q2/Q3, constant current source A10Q4 and series regulator A10Q1, form an adjustable voltage source whose output varies linearly with rotation of the TUNING control. Screwdriver controls A9R9 and A9R10 permit adjustment of minimum and maximum output voltages, respectively, so that the BWO can cover its required frequency range. The output of this adjustable voltage source is coupled through pins C and F of rear panel interlock J11/P4 (provided for remote programming of frequency) to the helix power supply (refer to paragraph 3-34).

3-28. SAWTOOTH INVERTER. When MHz/DIV pushbutton switch S8 is depressed and PHASE LOCK pushbutton switch S3 is released, dispersion range relay K3 is unenergized. Normally closed contacts 5-6 of K3 couple the sawtooth voltage generated within the Main Frame (refer to paragraphs 3-29 through 3-49 of the MF-100 Instruction Manual) from rear panel connector J2-H to an inverter consisting of differential amplifier A7Q9/Q10, amplifier A7Q8 and emitter follower A7Q7. The overall gain of the inverter is calibrated by screwdriver control A7R39, while negative feedback through A7R36 assures adequate linearity and dc stability. The inverted output is then applied to the wide dispersion control circuitry (refer to paragraph 3-29). Note that, when the SPA-3000 is set to the wide dispersion operating mode (with the PHASE LOCK pushbutton switch released), normally-open contacts 12-13 of K3 prevent the simultaneous application of the sawtooth voltage to the narrow band local oscillator within the Main Frame.

3-29. WIDE DISPERSION CONTROL. The broad input frequency range of the SPA-3000 is obtained by employing either the fundamental or harmonic (the latter developed within the first mixer) of the swept first local oscillator. Thus, if a sawtooth voltage V is required to sweep the first local oscillator ±1.5 GHz about a center frequency of 6 GHz (corresponding to a dispersion of 3 GHz when the RF-3000 is tuned to 2 GHz during band 1 operation), the second harmonic will be swept ±3 GHz about 12 GHz, the third harmonic ±4.5 GHz about 18 GHz, etc. It is readily apparent that, for the dispersion to remain constant independent of the local oscillator harmonic employed in the mixing process, the sawtooth sweep voltage must be attenuated by a factor n, where n = the harmonic employed. This attenuation is automatically introduced by the precision voltage divider consisting of RANGE switch S10A and precision resistors R55 through R61.

3-30. Once the appropriate sweep voltage amplitude for maximum (3 GHz) dispersion as a function of tuning band employed has been obtained, a second step of attenuation must be provided to obtain the desired sweep voltage for a selected dispersion. This second attenuator consists of FREQUENCY DISPERSION switch S9A and precision resistors R45 through R50. These two voltage divider networks enable the operator to select calibrated dispersions from 1 to 300 MHz/division, in a 1-3-10 sequence, during wide dispersion (swept front end) operation. FREQUENCY DISPERSION VARIABLE control R54, when rotated counterclockwise from its CAL position, permits vernier adjustment of the dispersion between calibrated steps. The sawtooth voltage level selected by the settings of the RANGE switch, FREQUENCY DISPERSION switch and FREQUENCY DISPERSION VARIABLE control settings is then applied to a helix power supply (refer to paragraph 3-34). Note that when the wide dispersion operating mode is selected (MHz/DIV pushbutton switch S8 depressed) and the operator depresses PHASE LOCK pushbutton switch S3 without first going into the narrow dispersion mode, relay K3 is energized, automatically placing the unit in the narrow dispersion mode.

3-31. NARROW DISPERSION CONTROL. The sawtooth voltage generated within the Main Frame (refer to paragraphs 3-29 through 3-49 of the MF-100 Instruction Manual) is coupled through rear panel connector J2-H and applied simultaneously to pin 5 of dispersion range relay K3 and FREQUENCY DISPERSION VARIABLE control R38. This single sawtooth voltage is employed to provide all calibrated dispersions up to 300 MHz/ division.

3-32. When kHz/DIV pushbutton switch S7 is depressed, -26 volts is impressed across the coil of dispersion range relay K3, energizing the relay and placing the SPA-3000 in the narrow dispersion

(swept IF) operating mode. This mode, which is functional for dispersions up to 300 kHz/division, operates in the same manner described in paragraphs 3-22 through 3-26 of the MF-100 Instruction Manual, except that the amplitude of the sawtooth voltage applied to the narrowband local oscillator within the Main Frame is selected by a duplicate calibrated voltage divider consisting of FREQUENCY DISPERSION switch S9C and resistors R67 and R39 through R44. Vernier reduction of the sawtooth voltage (hence dispersion) between calibrated steps is achieved by rotating FREQUENCY DISPERSION VARIABLE control R38 counterclockwise from its CAL position. Note that open contacts 5-6 of energized relay K3 prevent the applied sawtooth from reaching the sawtooth inverter.

3-33. Depression of 0 dispersion pushbutton switch S6 removes the sawtooth voltage from both the narrow dispersion control circuitry and the sawtooth inverter. However, the sawtooth output voltage at the wiper of S9C is open-circuited by the depression of S6, which puts the input to the narrowband local oscillator (within the Main Frame) at ground potential, resulting in the SPA-3000 operating in the 0 dispersion (neither front end nor IF being swept) mode.

3-34. HELIX POWER SUPPLY. The frequency of BWO V3 is an exponential function of the instantaneous helix-to-cathode voltage (see figure 3-5). Since all SIGNAL FREQUENCY GHZ scales are calibrated linearly in frequency, both the output voltage of the center frequency tuning circuit and position of the dial pointer are linear functions of TUNING control rotation, the voltage applied to the BWO helix must vary exponentially to obtain a linear change in frequency. This is accomplished by a shaping network in the feedback loop of the helix power supply.

3-35. The non-linear feedback loop is a voltage divider whose dropping leg is made up of resistors R16 through R20 in series and whose output leg is the diode segmentation network consisting of diodes A7CR1 through A7CR9, resistors A7R1 through A7R25 and associated circuitry. The exponential variation in output voltage with linear input voltage is achieved by biasing the diodes so that at the low end of the band, when the output of the center frequency tuning source is least negative, the output of the helix power supply is least positive. All the diodes in the feedback loop are back-biased and the equivalent impedance of the voltage divider output leg is maximum. The closed-loop gain of the supply is therefore a minimum, indicated by the slope of the helix voltage curve (figure 3-5) being at a minimum. As the TUNING control is rotated clockwise, the output of the helix supply becomes more positive, causing diodes A7CR1 through A7CR9 to sequentially become forward-biased. This causes the impedance of the divider output leg to decrease, increasing the closed loop gain. This process continues until diode A7CR9 is forward-biased, at which point the slope of the helix supply output voltage changes most rapidly for a given change in input voltage.

3-36. The point at which each diode becomes forward biased is determined by the voltage divider consisting of A7R1, A7R3 . . . . .A7R25, A7R28, the +11.3 volt supply and clamping diode A7CR10. Variable resistors A7R2, A7R5 . . . . .A7R23 and A7R26, in conjunction with fixed resistors A7R3, A7R6, ...A7R24 and A7R27, respectively, enable the output voltage of the helix voltage shaping amplifier to conform to the voltage-frequency characteristics of the individual BWO.

3-37. BWO PROTECTION CIRCUITS. The BWO is subject to permanent damage should either the maximum helix-to-cathode (helix) voltage or anode current rating be exceeded. Since the BWO is the most expensive component within the RF-3000, circuits are provided to insure that the tube is adequately protected to prevent these ratings from being exceeded.

3-38. High Voltage Clamp and Anode Supply Cut-out. The maximum helix voltage rating of the BWO is +1600 volts. Were it not for the high voltage clamp and anode supply cut-out circuitry, this limit could readily be exceeded (i.e., by rotating the TUNING control fully clockwise to its mechanical stop, which establishes a quiescent helix voltage of approximately +1450 volts, and employing dispersions of greater than 30 MHz/division during band 1 or band 2 operation, thereby producing a maximum instantaneous helix voltage in excess of +1600 volts).

3-39. The high voltage clamp consists of voltage comparator A7Q12/Q13 and emitter follower A7Q11 while the anode supply cut-out consists of voltage comparator A8Q9/Q10, emitter follower A8Q8 and silicon controlled rectifier A8CR1. The sensing inputs of both voltage comparators are tied to the BWO helix through a resistive voltage divider (R8 through R11, A7R73 and A7R74). The base of A7Q12 is maintained at a reference voltage of +6 volts while the base of A8Q9 is fixed at +6.6 volts.

3-40. As long as the instantaneous BWO helix voltage is equal to or less than +1450 volts (corresponding to an output frequency of approximately 8.25 GHz), the sensing input voltage to both comparators does not exceed their respective reference voltages, and emitter followers A7Q11 and A8Q8 are both held in cutoff. Should the instantaneous helix voltage rise above +1450 volts, the collector of A7Q12 will become sufficiently positive to drive emitter follower A7Q11 into conduction. The output of A7Q11 is fed back to the input of the helix voltage shaping amplifier where it is added to the dispersion control waveform. Being of opposite polarity, this feedback opposes the effect of the dispersion control waveform driving the helix voltage beyond +1450 volts.

3-41. If, for any reason (i.e., component failure within the high voltage clamp circuit), the helix voltage exceeds +1500 volts, emitter follower A8Q8 is driven into conduction. When the helix voltage nears the rated limit of +1600 volts, the voltage

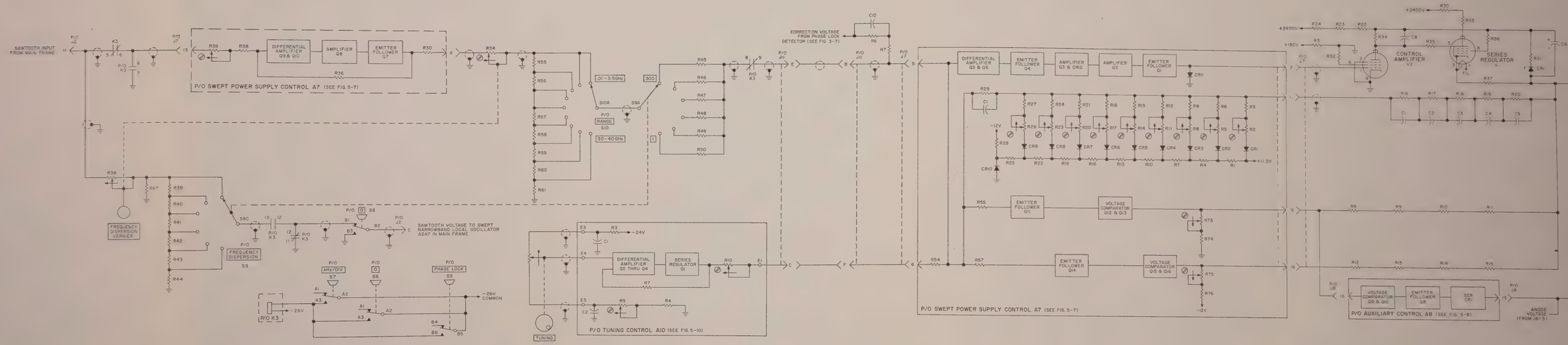


Figure 3-4. Tuning and Dispersion Control Circuitry, Detailed Block Diagram

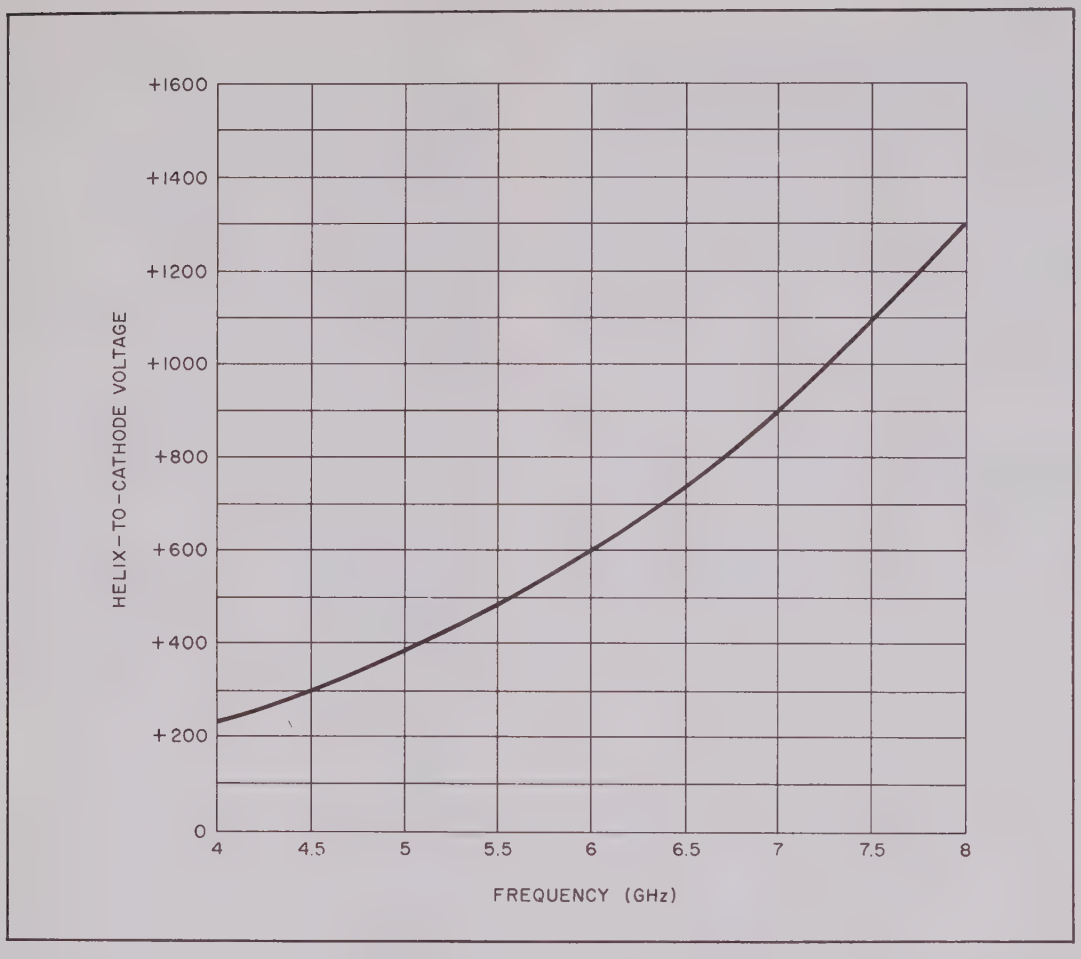


Figure 3-5. Typical Frequency Versus Helix-to-Cathode Voltage Characteristics of BWO V3

at the control electrode of A8CR1 is positive to trigger the SCR. The anode power supply is shorted to ground through the triggered SCR and the overload protection circuitry within the anode power supply (refer to paragraph 3-67) senses an overload condition, current-limiting the supply. Although helix voltage is still being applied to the BWO, the danger of helix structure damage is removed since beam current cannot be sustained without anode voltage. The anode power supply will remain disabled until LO ENABLE pushbutton switch S2 is released and depressed again. Failure to correct the malfunction will result in a repetition of the cycle when the LO ENABLE pushbutton switch is depressed again.

3-42. Low Voltage Clamp. The maximum anode current rating of BWO V3 is 12 ma; helix voltages below rated anode voltage would cause the anode structure to draw excessive current. The low voltage clamp, in conjunction with the current-limited anode power supply (refer to paragraph 3-67), prevents such damage.

3-43. The low voltage clamp consists of voltage comparator A7Q15/Q16 and emitter follower A7Q14. The base of A7Q16, the sensing input of the voltage comparator, is tied to the BWO helix through the resistive voltage divider consisting of R12 through R15, A7R75 and A7R76. The other end of the divider is at -12 volts. The base of A7Q15 is fixed at a reference voltage of -6 volts. As long as the instantaneous BWO helix voltage is equal to or greater than +180 volts, the sensing input voltage to the comparator is less negative than the reference voltage and emitter follower A7Q14 is held in cutoff.

3-44. Should the instantaneous helix voltage drop below +180 volts, the collector of A7Q15 will become sufficiently negative to drive A7Q14 into conduction. The output of A7Q14 is fed back to the input of the helix voltage shaping amplifier where it is added to the dispersion control waveform. Being of opposite polarity, this feedback opposes the effect of the dispersion control waveform driving the helix voltage below +180 volts.

3-45. SIGNAL IDENTIFIER. When employing the wide dispersion (swept front end) capability of the SPA-3000 to search for the presence of signals, quite often many pips appear simultaneously on the CRT. These pips fall into three categories.

a. True Responses. Applied signals (within the frequency limits of the selected RANGE switch,

TUNING control and DISPERSION switch settings) that produce a first IF when either 4 GHz (bands 1 and 3 through 9) or 2.08 GHz (band 2) below the instantaneous frequency of the proper swept first local oscillator harmonic.

b. Image Responses. Applied signals outside the frequency limits of the selected RANGE switch setting that produce a first IF when either 4 GHz (bands 1 and 3 through 9) or 2.08 GHz (band 2) above the instantaneous frequency of the proper swept first local oscillator harmonic.

c. Out-of-Band Multiple Responses. Applied signals outside the frequency limits of the selected RANGE switch setting that produce a first IF when either 4 GHz (bands 1 and 3 through 9) or 2.08 GHz (band 2) below or above the instantaneous frequency of an improper swept first local oscillator harmonic.

3-46. Unlike the swept IF (narrow dispersion) capability of the SPA-3000, where the type of response can be determined by noting the direction of pip travel with respect to TUNING control rotation and the proper viewing band calculated by noting the pip displacement for a given dispersion and change in center frequency tuning, all three types of responses travel in the same direction and with the same velocity for a given dispersion and change in center frequency tuning when the swept front end operating mode is employed. A foolproof, easy-to-operate signal identifier circuit (see figure 3-6) enables the operator to quickly determine the type of response an individual pip is and the proper band to view the signal.

3-47. During scanning procedures, the operator adjusts the TUNING control to position an individual pip at the CRT graticule f_0 vertical line and, with the FREQUENCY DISPERSION VARIABLE control rotated fully clockwise to CAL, rotates the FREQUENCY DISPERSION switch counterclockwise in one step increments (while maintaining the pip centered on the display by fine adjustment of the TUNING control)to 1 MHz/division. The display dispersion for a true or image response is therefore 10 MHz, while that for a multiple response is

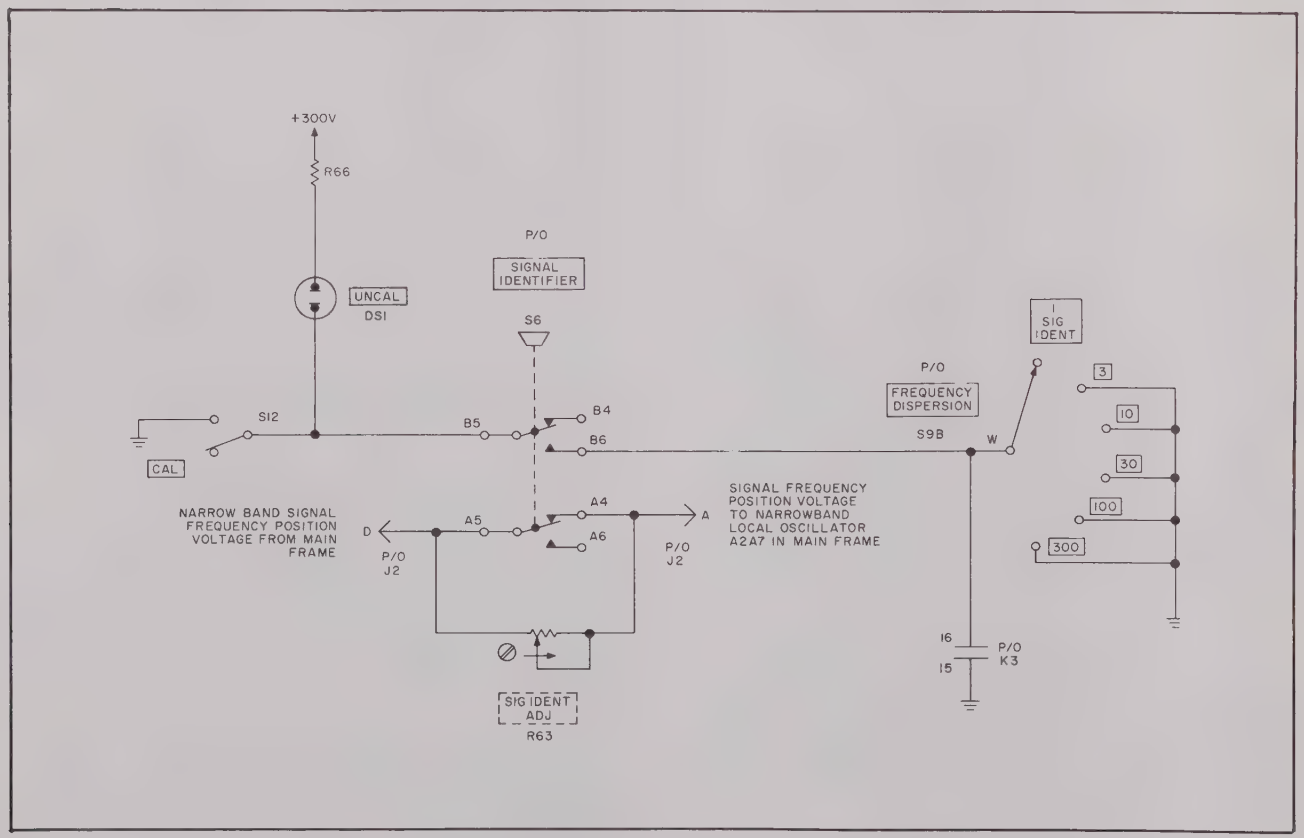


Figure 3-6. Signal Identifier Circuitry, Schematic Diagram

$$D \text{ (in MHz)} = \frac{10\ m}{n}$$

where

m = higher or lower harmonic number

and

n = proper LO harmonic number for selected setting of RANGE switch.

Thus, if the pip is due to an applied signal mixing with a lower harmonic, the dispersion will be less than 10 MHz; conversely, if due to mixing with a higher harmonic, the dispersion will be greater than 10 MHz.

3-48. By momentarily depressing SIGNAL IDENTIFIER pushbutton switch S6, the operator inserts Sig Ident Adj control R63 into the center frequency position control line of narrowband local oscillator A2A7Q5 within the Main Frame (refer to paragraphs 3-22 through 3-26 of the MF-100 Instruction Manual). This causes the narrowband local oscillator frequency (which is not swept during swept front end operation) to shift from 100 MHz to 101 MHz, resulting in a pip appearing 1 MHz earlier on the display. Thus, if the pip is due to a true response, depression of the SIGNAL IDENTIFIER pushbutton switch will cause the pip to shift one division to the left, indicating that the signal is being viewed on the correct setting of the RANGE switch. Should the pip move more or less than one division to the left, the signal is heterodyning with an improper LO harmonic (for that particular setting of the RANGE switch). The RANGE switch should be set to the next higher or lower band, respectively, and the process repeated until a pip shift of one division to the left is obtained, indicating that the signal is being viewed on the correct band. If the pip shifts to the right, an image response is being observed.

3-49. PHASE LOCK LOOP. (See Figure 3-7.)

3-50. The frequency stability and incidental FM of the BWO first local oscillator (which is fixed-tuned during swept IF operation) limits the display resolution when employing narrow dispersions. By using a tunable crystal reference oscillator to phase lock the BWO, resolutions of 1 kHz can be obtained throughout the entire .01 to 40 GHz frequency range of the instrument. The phase lock loop is completed by depression of PHASE LOCK pushbutton switch S3, which automatically places the SPA-3000 into the swept IF operating mode.

3-51. 29 MHZ PULLED OSCILLATOR A11. Crystal-controlled oscillator A11Q1 provides a stable reference signal for the phase lock loop. PHASE LOCK ADJUST capacitor A11C1, in series with quartz crystal A11Y1 (which is series-resonant at 29.150 MHz) permits pulling of the oscillator frequency over a range of 120 kHz, thereby allowing the operator to vary the oscillator frequency approximately 0.4 percent.

3-52. COMB GENERATOR A12A1. The output of the 29 MHz pulled oscillator is coupled to 29 MHz power amplifier A12A1Q1. This amplifier provides the reference signal with sufficient gain to drive harmonic generator A11A1CR1, a step-recovery diode which produces harmonics (up to 8 GHz) of the applied signal. The output of the comb generator is coupled through 6 dB pad A12AT1, 4 GHz high-pass filter A12FL1 and 6 dB pad A12AT2 to directional coupler A12DC1.

3-53. DIRECTIONAL COUPLER A12DC1. The comb of frequencies spaced approximately every 29 MHz above 4 GHz is applied to the straight-through line of directional coupler A12DC1. The BWO output (obtained from port A of V3) is applied to the directional input of A12DC1 via the closed contacts of energized coaxial relay A1K5 (energized when the PHASE LOCK pushbutton switch is depressed) and 6 dB pad A1AT5. The directional coupler injects the BWO output upon the low-level comb generator output and the composite signal is coupled through 4 to 8 GHz isolator A12AT3 to phase lock mixer A12CR1.

3-54. PHASE LOCK MIXER A12CR1 AND 21 MHZ AMPLIFIER A12A2. The composite signal applied to the phase lock mixer consists of the BWO output and the comb of frequencies above 4 GHz. By manual tuning of PHASE LOCK ADJUCT control A12A1C1, the frequency of the 29 MHz pulled oscillator can be adjusted so that one of the harmonics developed by the comb generator will be exactly 21 MHz away from the sampled BWO signal. When this occurs, the mixer develops a 21 MHz IF signal. This signal is coupled to 21 MHz amplifier A12A2, where it undergoes a single stage of amplification prior to being applied to 21 MHz amplifier/limiter A2A1.

3-55. 21 MHZ AMPLIFIER/LIMITER A2A1. The output of A12A2 is applied to A2A1 where it undergoes two stages of amplification. The output of the second amplifier stage is limited to eliminate amplitude variations due to fluctuations in comb generator harmonic level, noise, etc. The output of the 21 MHz amplifier/limiter is then applied to phase detectors A2A3 (refer to paragraph 3-57).

3-56. 21 MHZ REFERENCE OSCILLATOR A2A2. A 21 MHz phase reference signal is generated by a stable crystal-controlled oscillator consisting of A2A2Q1 and A2A2Y1. This signal is amplified by A2A2Q2 and coupled to phase detectors A2A3.

3-57. 21 MHZ PHASE DETECTORS A2A3. The 21 MHz phase reference output of A2A2 is coupled to A2A3 and applied to two synchronous phase detector networks: a locking phase detector (consisting of diodes A2A3CR1 through A2A3CR4 and transformers A2A3T1 and A2A3T3) via a voltage divider formed by A2A3R9 and A2A3R7 and an indicator phase detector (diodes A2A3CR5 through A2A3CR8 and transformers A2A3T2 and A2A3T4) via a 90° phase-lag network consisting of A2A3R8 and A2A3C6. The 21 MHz output of A2A1 is simultaneously coupled directly to the primary of A2A3T1 and, through amplifier A2A3Q1 to the primary of A2A3T2.

3-58. When the instantaneous output of A2A1 is either in phase with or 180° out-of-phase with the output of the phase reference oscillator, the output of the locking phase detector is zero volts. The inputs to the indicator phase detector at this instant will be out-of-phase by 90° and the output of the indicator phase detector will be at either a positive or negative peak. This causes PHASE LOCK ADJUST indicator DS2 to illuminate (refer to paragraph 3-60), informing the operator that a true phase lock has been obtained.

3-59. After a phase lock has been obtained, any environmental and/or electrical variation tending to cause the BWO frequency to increase or decrease will result in a change in phase relationship between the output of A2A1 and the phase reference oscillator output, causing the output of the phase reference detector to deviate from 0 volts. Thus, if the BWO frequency increases slightly, the phase lead or lag between the output of A2A2 and the phase reference oscillator will increase or decrease, respectively, the output of the locking phase detector will become positive. Conversely, if the BWO frequency decreases slightly, the phase lead or lag will decrease or increase, respectively, the locking phase detector will become negative. Any such change in locking phase detector output from 0 volts is fed back (through a compensation network consisting of R6, R7 and C10) to the helix power supply, where it adjusts the helix voltage to maintain a phase lock condition.

3-60. PHASE LOCK INDICATOR. When the phase difference between the output of A2A1 and A2A2 is not near 90°, the output of the indicator phase detector within A2A3 is not at its positive or negative maximum and the biasing of transistors A8Q4 through A8Q8 is such to maintain A8Q5 and A8Q7 in cutoff and A8Q4 and A8Q8 in saturation. A8Q5 being in cutoff prevents PHASE LOCK ADJUST indicator DS2 from illuminating. When a phase lock is achieved and a positive maximum is produced by the indicator phase detector, A8Q5 is driven into saturation and DS2 illuminates. Conversely, if a negative maximum is provided, A8Q7 is driven into saturation. This drives A8Q6 into saturation, causing A8Q4 to go into cutoff and placing A8Q5 into saturation, thereby illuminating DS2.

3-61. RF MARKER. (See Figure 3-8).

3-62. When RF MARKER pushbutton switch S4 is depressed, relay A1K5 is unenergized and the output of swept first local oscillator is coupled through the normally closed contacts of A1K5 and 20 dB attenuator A1AT6 through the straight section of T A13CP1 to short circuit stub A13W2. Diode detector A13CR1, mounted in T leg of A13CP1, is located one-half wavelength (at 400 MHz) from the short. Thus, as the BWO sweeps across its frequency range from 4.01 to 8.08 GHz, a standing-wave will be established. The amplitude of the standing wave at the T section of A13CP1 will be 0 when the instantaneous BWO frequency is a multiple of 400 MHz (i.e., 4.4 GHz, 4.8 GHz, etc.). When the instantaneous BWO frequency is not a multiple of 400 MHz, the voltage at the T section will be high between these nulls.

3-63. Diode A13CR1 detects the standing wave and applies it to the base of A8Q1, the input of a voltage comparator. The voltage comparator continually senses the output of detector A13CR1 and, whenever this level falls below a preset threshold level (indicating that the BWO frequency is at or very close to a multiple of 400 MHz), emitter follower A8Q3 is driven into conduction to provide a positive output pulse. This pulse is coupled to the video amplifier within the Main Frame and appears as a marker pip on the display. The threshold level is set by A8R5.

3-64. POWER SUPPLIES.

3-65. The dc voltages required for operation of the RF-3000 are obtained from self-contained supplies; no power is drawn from the Main Frame.

3-66. POWER INPUT CIRCUITRY. 115 or 230 volt, 47 to 63 Hz, single-phase power is coupled through polarized connector P3 (see figure 5-1) and applied, unswitched, to receptacle J10 where it is available for application to auxiliary equipment. When SYSTEM POWER pushbutton switch S1 is depressed and 115/230 volt switch S11 is set to the position corresponding to the available line voltage, 115 volts is applied to blower B1, the heater of delay relay K2 and the dual primaries of both T1 and T3. After a 60 second delay, the contacts of K2 close and 115 volts is applied to the coil of hold relay K1, establishing a path through now-closed contacts K1-1 and 2 to maintain the relay energized. Energization of hold relay K1 applies 115 volts to the dual primaries of T2, which drives both the helix and anode power supplies. The delay introduced by K2 allows the BWO cathode to become heated before application of helix and anode voltage, thereby preventing possible damage to the BWO due to cold cathode emission.

3-67. HELIX POWER SUPPLY. The helix power supply (see figure 5-1) consists of full-wave bridge rectifier CR2 through CR5, control amplifier V2 and series regulator V1. The output level of this supply is determined by the setting of the TUNING control alone (during swept IF operation - dispersions up to 300 kHz/division) or the TUNING control and either the instantaneous dispersion control sawtooth voltage (during swept front end operation - dispersions above 300 kHz/division) or the instantaneous output of the locking phase detector (during phase lock operation - dispersions up to 300 kHz/division).

3-68. +180 V/ANODE POWER SUPPLY A6.

3-69. +300 Volt Supply. The +300 volt unregulated supply (see figure 5-6) consists of full-wave rectifier A9CR1 and A9CR2 and filter capacitor A9C1. The output of this unregulated supply is used to illuminate PHASE LOCK ADJUST and UNCAL indicators DS2 and DS1, respectively, as well as drive the +180 volt supply.

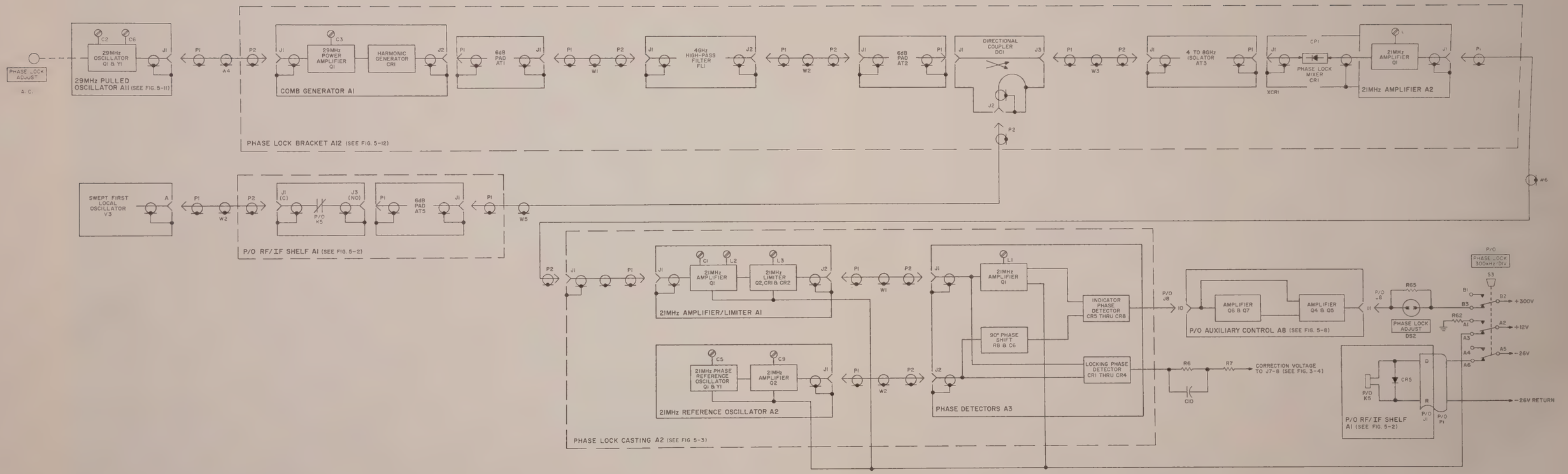


Figure 3-7. Phase Lock Loop, Detailed Block Diagram

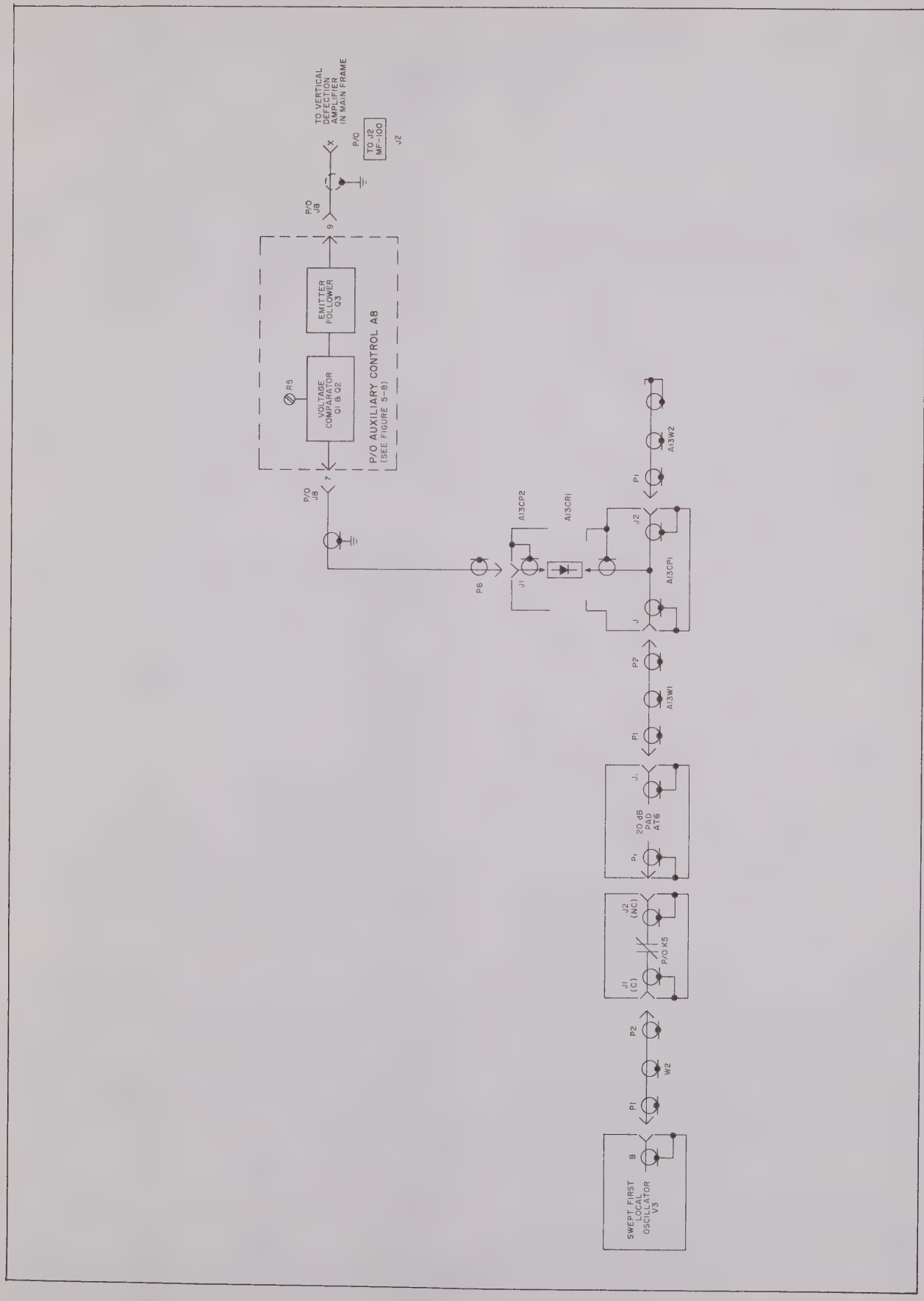


Figure 3-8. RF Marker Circuitry, Detailed Block Diagram

3-70. +180 Volt Supply. The +300 volts from A9C1 is coupled through dropping resistor A9R1 and applied across zener regulator A9CR3. The output voltage, taken across the filter consisting of A9R19 and A9C2, is coupled through J9-15 to serve as the screen supply for control amplifier V2 and the drive voltage (when LO ENABLE pushbutton switch S2 is depressed) for the BWO anode supply.

3-71. BWO Anode Supply. The BWO anode supply (see figure 5-6) is a constant-voltage current-limiting regulator. The output voltage level is set between +50 and +90 volts (depending on the data stamped on the nameplate of the BWO) by means of screwdriver control A6R18. Any variation in anode voltage level is sensed by voltage comparator A6Q8/Q9, amplified by A6Q4/Q5 and A6Q7 and fed back to the bases of series regulators A6Q1/Q2/Q3. This feedback changes the effective collector-to-emitter resistance and allows the output voltage to remain fixed at its desired level.

3-72. Current limiting at 12 ma is provided by a short circuit protection network comprised of A6Q6, zener diode A6CR5 and dropping resistor A6R20. Should the anode supply draw excessive current (either due to the helix voltage dropping too low or a short circuit to ground), the voltage drop across A6R20 becomes large enough to forward bias the base-to-emitter junction of A6Q6 and drive diode A6CR5 into its breakdown region. Feedback to the bases of A6Q1 through A6Q3 adjusts the conduction of the series regulators to limit the anode current, thereby protecting both the supply and BWO from damage.

3-73. ±12 VOLT POWER SUPPLY A3/A4. The ±12 volt supplies (see figure 5-4) are two identical circuits; the +12 volt supply has its low output tied to ground while the -12 volt supply has its high output tied to ground. Since both supplies are identical, only the +12 volt supply will be discussed. A full-wave bridge rectifier (A3CR1 through A3CR4) and filter (A3C1, A3R1 and A3C2) provides the unregulated power employed to drive a voltage regulator consisting of Q1, A4Q1 through A4Q4 and associated circuitry. The output level of the voltage regulator is set at +12 volts by screwdriver adjustment A4R8. Any variation in output voltage due to changes in current drawn from the supply and/or line power voltage fluctuations are sensed and amplified by voltage comparator A4Q3/Q4 and applied to series regulators Q1 and A4Q1, changing their effective emitter-to-collector dynamic resistance in that direction which returns the output of the supply to the preset value of +12 volts. Current limiting of the supply output is achieved by A4Q2 and A4R10. Should more than 1 ampere be drawn from the supply, the voltage across A4R10 will drive A4Q2 into its linear region of operation effectively reducing the gain of the voltage comparator. This, in turn, alters the amount of current passed by the series regulators. Therefore, even under short circuit conditions, the +12 volt supply is protected against component failure due to overload.

3-74. +11.3 VOLT REFERENCE SUPPLY. +11.3 volts of low ripple and noise content (employed solely in the diode segmentation feedback network in the helix power supply) is obtained from the +12 volt regulated line by means of series regulator A8Q11 differential amplifier A8Q12/Q13 and associated circuitry (see figure 5-8). The emitter-to-base voltage of A8Q11 (developed across A8R36) maintains the voltage at the collector of the transistor at +11.3 volts.

3-75. -24 VOLT POWER SUPPLY A9.

3-76. -26 Volt Supply. The -26 volt unregulated supply (see figure 5-9) consists of full-wave bridge rectifier A9CR1 through A9CR4 and filter capacitor A968. The nominal -26 volt output of this supply is employed to drive the -24 volt supply as well as relays K3, A1K1 through A1K5 and A1A1K1.

3-77. -24 Volt Supply. The -24 volt supply (see figure 5-9) is a highly-stable, constant-voltage, current-limiting regulator consisting of series regulator A9Q1, voltage comparator A9MC1, short circuit protector A9Q2 and associated circuitry. The output level of the supply, which is low in ripple and noise content, is set at -24 volts by A9R8. A9Q2, in conjunction with A9R3, limits the maximum current that can be drawn from the supply at 50 milliamperes.

3-78. -12 Volt Supply. A second -12 volt supply (of low ripple and noise content which is employed solely for powering second local oscillator A1A3) consists of series regulator A9Q3, voltage comparator A9MC2, short circuit protector A9Q4 and associated circuitry. The output level of this supply (nominally -12 volts) is determined by the output of the -24 volt supply. A9Q4, in conjunction with A9R12, limits the maximum current that can be drawn from the regulator at 10 milliamperes.

3-79. -6.3 VOLT BWO FILAMENT POWER SUPPLY A5. Regulated -6.1 volts employed solely for BWO filament power is derived from a full-wave bridge rectifier (A5CR1 through A5CR4) and a conventional voltage regulator (A5Q1 through A5Q4 and associated circuitry - see figure 5-5). The output of the supply is set at -6.1 volts by A5R8. Total time indicator A5TT1 provides a visual indication of the total time that filament power has been coupled to the BWO.

SECTION IV
MAINTENANCE

4-1. GENERAL

4-2. This section contains maintenance, alignment and calibration instructions for the RF-3000. Included are a list of test equipment required to maintain the equipment, minimum performance standards checks to determine whether the RF-3000 operates within the electrical specifications listed in table 1-2, symptomatic and systematic troubleshooting procedures to localize a malfunction to an individual subassembly or circuit, and alignment and calibration procedures necessary to restore the RF-3000 to proper operating condition after the required repairs have been effected.

4-3. TEST EQUIPMENT REQUIRED.

4-4. The test equipment required for the maintenance, alignment and calibration of the RF-3000 is listed in table 4-1. Equipment of equivalent characteristics may be substituted for any item listed in the table.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Nomenclature	Manufacturer and Model
Signal Generator	HP-608F (10-455 MHz); HP-612A (450-1230 MHz); HP-8614A (0.8-2.4 GHz); HP-8616A (1.8-4.5 GHz); HP-618C (3.8-7.6 GHz); HP-620B (7-11 GHz); HP-626A (10-15.5 GHz); HP-628A (15-21 GHz)
Frequency Doubler	HP-938A (18-26.5 GHz); HP-640A (26.5-40 GHz)
Power Divider	Weinschel 1506
Magic Tee	Merrimac CHT-3K, CHT-6K and CHT-9.0K
Crystal Tester	Airborne Instruments 391
Crystal Detector	HP-423A (2 required)
Load Resistor	HP-11523A (2 required)
Variable attenuator	Weinschel 953 and Filmohm TA-700
50 Ohm Termination	Weinschel 535-MN and 535-MT
VOM	Simpson 260

TABLE 4-1. REQUIRED TEST EQUIPMENT (Cont)

Nomenclature	Manufacturer and Model
Sampling Tee.	Microlab NY-10N
Power Meter	HP-432A
Thermistor Mount	HP-478A
Counter	HP-5245L and HP-5244L
Frequency Converter	HP-5254B
Digital Voltmeter	Singer/Ballantine 3570/3572
Frequency Meter	HP-536A
Comb Generator	HP-8406A
Sweep Generator	Jerrold 900B
Detector	Jerrold D-50B
Clip-on Milliammeter	HP-428B
Step Attenuator	HP-355C (2 required)
Oscilloscope	Tektronix 545A with CA plug-in; HP-130C
Sweep Oscillator Frame	HP-8690B
Control Unit	HP-8706A
RF Unit Holder	HP-8707A
RF Unit	HP-8699B (0.1-4 GHz); HP-8693A (4-8 GHz); HP-8694B (8-12.4 GHz) HP-H01-8694B(7-12.4 GHz)
Attenuator	Narda 777-10; Narda 777-20; Narda 777T-6; Narda 777T-10

4-5. MINIMUM PERFORMANCE STANDARDS.

4-6. The minimum performance standards checks of table 4-2 is a sequential series of tests which determines if the RF-3000 is functioning within the electrical specifications of table 1-2. If the equipment fails to provide the "acceptable indication"

specified, the operator should refer to the applicable troubleshooting, replacement, repair, alignment and/or calibration procedure to correct the defect.

NOTE

These minimum performance standards checks presupposes that the Main Frame is working properly. To verify that plug accessory connector (Singer Part No. 556146-754) into AUXILIARY MODULE connector J2, located on the rear panel of the Main Frame, and then perform the minimum performance standards checks contained in paragraph 4-5 of the MF-100 instruction manual. After these checks have been successfully completed, replace the supplied multiconductor patch cable between the RF-3000 "TO J2 MF-100" and Main Frame "AUXILIARY MODULE" rear panel connectors and then proceed to table 4-2.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
1	To prepare the SPA-3000 for testing.	Connect the Main Frame and RF-3000 together and apply power to the equipment as directed in paragraphs 2-4 through 2-8. Perform the preliminary adjustments of paragraph 2-12.	
2	To evaluate frequency accuracy.	a. Connect an HR8406A comb generator, set to provide 100 MHz markers, to the SIGNAL INPUT .01-12.4 GHz input jack. b. Set the RANGE switch to .01-3.5 GHz and set the FREQUENCY DISPERSION switch for 30 MHz/DIV. c. Set the TUNING control to obtain pointer indications listed below on the SIGNAL FREQUENCY GHz scale and, for each setting, note the marker pip displacement from the CRT f_0 vertical graticule line. .01-3.5 GHz Dial Indication 1. "Zero frequency" pip 2. 0.4 3. 0.8 4. 1.2 5. 1.6 6. 2.0 7. 2.4 8. 2.8 9. 3.2 10. First mark to right of scale 11. Second mark to right of scale	c. Specification: ±1% of L.O. frequency. Permissible marker pip displacement 1. 40 MHz (1 1/3 divisions) 2. 44 MHz (1 7/15 divisions) 3. 48 MHz (1 3/5 divisions) 4. 52 MHz (1 11/15 divisions) 5. 56 MHz (1 13/15 divisions) 6. 60 MHz (2 divisions) 7. 64 MHz (2 2/15 divisions) 8. 68 MHz (2 4/15 divisions) 9. 72 MHz (2 2/5 divisions) 10. 76 MHz (2 8/15 divisions) 11. 80 MHz (2 2/3 divisions)
3	To evaluate dispersion linearity (swept front end operation).	Adjust the TUNING control to obtain the following pointer indications on the SIGNAL FREQUENCY GHZ scale: 0.8, 1.6, 2.4, 3.2 and the first mark to the right of the calibrated scale (corresponding to a signal frequency of 3.6 GHz). Three pips will appear on the screen for each setting of the TUNING control. Carefully adjust the TUNING control so that the middle pip is at the graticule f_0 line. Note the horizontal spacing between individual pips.	The ratio of the maximum to minimum horizontal spacing between individual pips shall not exceed 1.2.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

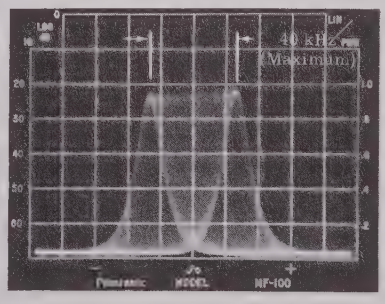
STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
4	To evaluate accuracy of calibrated dispersion steps (swept front-end operation).	a. Set the Main Frame controls as follows: BANDWIDTH switch — 100 kHz MARKER MODULATION switch — OFF AMPLITUDE SCALE switch — LOG SWEEP switch — 3 MS/DIV SWEEP/SYNC switch — INT b. On the RF-3000 depress the MHz/DIV pushbutton; set the FREQUENCY DISPERSION switch to 300; set the TUNING control to 1.8 GHz. c. Adjust the TUNING dial to align a single line of the displayed comb generator output with the left-most CRT vertical graticule line. d. Count the total number of lines displayed within the graticule limits and determine the total graticule-displayed dispersion. e. Repeat steps 4c and 4d for the following frequency dispersion settings and comb generator outputs: Dispersion Range — Comb Generator Output 100 MHz/DIV — 100 MHz 30 MHz/DIV — 10 MHz 10 MHz/DIV — 10 MHz 3 MHz/DIV — 1 MHz 1 MHz/DIV — 1 MHz	d. Specification: ±5% ±2 MHz for dispersion ranges above 1 MHz/division. Dispersion displayed is 3000 ± 152 MHz. e. Dispersion Displayed 1. 1000 ± 52 MHz 2. 300 ± 17 MHz 3. 100 ± 7 MHz 4. 30 ± 3.5 MHz 5. 10 ± 2.5 MHz
5	To evaluate incidental FM and phase lock operation.	a. Rotate the FREQUENCY DISPERSION VARIABLE control fully clockwise to CAL. Set the BANDWIDTH switch to 1 kHz; set the SWEEP switch to 300 μS/DIV; and set the FREQUENCY DISPERSION switches for 10 kHz/DIV. Set the comb generator for 100 MHz markers. b. Set the TUNING control to obtain pointer indications, in sequence, of .1, 2, and 3.4 on the SIGNAL FREQUENCY GHz scale and, at each frequency, center a comb line at the CRT f_o vertical graticule line. Note the display. c. Set the FREQUENCY DISPERSION switches for 1 kHz/DIV, depress the PHASE LOCK pushbutton switch and carefully adjust the	b. Specification: 40 kHz peak-to-peak (maximum) on L. O. fundamental. See figure below.  c. Specification: 1 kHz peak-to-peak overall (maximum) on L. O. fundamental.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
5 Cont.		PHASE LOCK ADJUST control until the PHASE LOCK ADJUST indicator illuminates. d. Release the PHASE LOCK pushbutton switch, set the RANGE switch to 3-6 GHz and adjust the TUNING control to obtain a pointer indication of 3.1 GHz. Center the pip on the CRT. Note the display e. Repeat step 5c.	 d. Same as 5b. e. Same as 5c.
6	To evaluate residual responses.	a. Release the PHASE LOCK pushbutton switch and disconnect the comb generator from the SIGNAL INPUT .01-12.4 GHz jack. Set the FREQUENCY DISPERSION switches for 1 MHz/DIV; set the BANDWIDTH switch to 100 KHz; set the SWEEP switch to 3 MS/DIV, set the RANGE switch to .01-3.5 GHz and adjust the TUNING control to obtain a pointer indication at the low end of the band. Set the RF ATTENUATOR dB switch to 60 dB. b. Slowly rotate the TUNING control through the entire band, noting both the amplitude and frequency of any residual response. c. Set the RF ATTENUATOR dB switch to 0 dB and tune an HP-608F (10-455 MHz), HP-612A (0.45-1.23 GHz), HP-8614A (0.8-2.4 GHz) or HP-8616A (1.8-4.5 GHz) signal generator, as required, to obtain a cw output of -90 dBm for each frequency noted in 6b. Connect the appropriate signal generator to the SIGNAL INPUT .01-12.4 GHz connector and compare the indicated amplitude of a -90 dBm input signal with the notated amplitudes of step 6b. d. Set the RF ATTENUATOR dB to 60 dB; set the RANGE switch to 3-6 GHz and slowly rotate the TUNING control through the entire band, and again note both the amplitude and frequency of any residual response. e. Repeat step 6c using an HP-8616A (1.8-4.5 GHz) or HP-618C (3.8-7.6 GHz) signal generator, as required.	 c. Specification: Less than -90 dBm referred to signal input on fundamental mixing. Observed -90 dBm input signal amplitude shall not be greater than residual response. e. Same as 6c.
7	To evaluate operation of signal identifier	a. Disconnect the signal generator, set the RANGE switch to .01-3.5 GHz and adjust the TUNING control to observe a 300 MHz input signal. Tune an HP-608F signal generator for a cw output of 300 MHz at -60 dBm, and connect it to the SIGNAL INPUT .01-12.4 GHz jack. Position the pip at the CRT f_o vertical graticule line. b. Press the SIGNAL IDENTIFIER pushbutton while observing the 300 MHz pip.	 b. Specification: Single pushbutton switch provided to assure proper band selection. Pip is displaced one division to left of f_o.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
7 Cont		c. Release SIGNAL IDENTIFIER pushbutton; set the RANGE switch to 4.5-10 GHz and repeat step 7b.	c. Pip is displaced 2 divisions to left of f_o.
		d. Release SIGNAL IDENTIFIER pushbutton; set the RANGE switch to 9-12.4 GHz and repeat step 7b.	d. Pip is displaced 3 divisions to left of f_o.
8	To evaluate RF markers	a. Remove the signal generator; set the RANGE switch to .01-3.5 GHz; set the FREQUENCY DISPERSION switches for 10 MHz/DIV and adjust the TUNING control for a pointer indication just to the left of .01 on the SIGNAL FREQUENCY GHz scale. Note the appearance of a "zero frequency" pip on the display: this corresponds to the instantaneous 4 GHz output of the swept first LO.	
		b. Adjust the IF ATTENUATOR decades switch, as required, to obtain a "zero frequency" pip amplitude no greater than 40 on the graticle LOG scale.	
		c. Depress the RF MARKER pushbutton switch and observe the graticule display.	c. Specification: 11 markers, at 400 MHz increments, on local oscillator fundamental 4 to 8 GHz range. Marker is superimposed upon the "zero frequency" pip.
		d. Rotate the TUNING control clockwise and note the pointer indication on the SIGNAL FREQUENCY GHz scale at which an RF marker pip appears at the CRT f_o graticule line.	d. RF markers appear at pointer indications of 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.8, and 3.2 as well as each of the two vertical lines to the right of the calibrated scale (corresponding to 3.6 and 4.0).
9	To evaluate noise sidebands.	a. Release the RF MARKER pushbutton switch; set the FREQUENCY DISPERSION switches for 30 kHz/DIV; set the BANDWIDTH switch to 1 kHz; set the IF ATTENUATOR switches to 00 dB; adjust the IF gain control for one-half division noise, connect an HP-8416A signal generator, set to 2 GHz at -65 dBm to the SIGNAL INPUT .01-12.4 GHz jack; adjust the TUNING control to position the pip at the CRT f_o vertical graticule line.	
		b. Depress the PHASE LOCK pushbutton and rotate the PHASE LOCK ADJUST control until the PHASE LOCK ADJUST indicator illuminates.	
		c. Increase the signal generator output for a full-scale LOG presentation, and note the amplitude of the noise side-bands 30 kHz (1 division) either side of the displayed signal.	c. Specification: Greater than 60 dB below cw signal level 30 kHz or more away from signal, using fundamental mixing with 1 kHz bandwidth. See figure below:

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

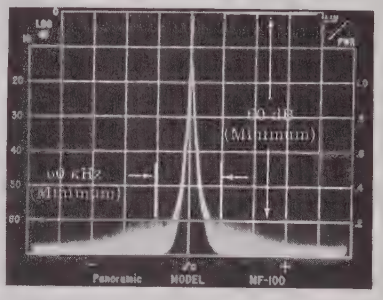
STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
9 Cont			
10	To evaluate RF sensitivity and flatness.	a. Disconnect the signal generator. Release the PHASE LOCK pushbutton switch and rotate the BANDWIDTH VARIABLE control fully counterclockwise. b. With the kHz/DIV pushbutton switch depressed, set the BANDWIDTH switch to 100 kHz, set the FREQUENCY DISPERSION switch to 300 and set the AMPLITUDE SCALE switch to PWR. Rotate the IF GAIN control fully counterclockwise. c. Set the TUNING control for an indication of 0.1 GHz. d. Adjust the IF GAIN control to obtain an integrated noise display coincident with the graticule PWR scale .2 horizontal line. e. Tune an HP-608F (set for levelled output) for a cw output of -55 dBm at 100 MHz. Connect the equipment as illustrated in figure 4-1. f. Adjust the signal generator output level until the peak of the signal pip coincides with the graticule PWR scale .4 horizontal line. Note the signal generator output level. g. Set the AMPLITUDE SCALE switch to LOG (the base line of the display will rise and the signal pip will fall into the noise), depress the MHz/DIV pushbutton switch and set the BANDWIDTH switch to 100 kHz.	f. Specification: Band / Minimum Sensitivity / Response (Full Range) 1 / -105 dBm / ± 3.0 dB* 2 / -105 dBm / ± 3.0 dB 3 / -100 dBm / ± 4.5 dB 4 / - 95 dBm / ± 3.5 dB 5 / - 95 dBm 6 / - 90 dBm 7 / - 85 dBm 8 / - 80 dBm 9 / - 75 dBm *From 1 to 3.5 GHz; ±3.5 dB from .01 to 1 GHz. Signal generator output level does not exceed -65 dBm. (See note following table 4-2.)

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
10 Cont		h. Set the FREQUENCY DISPERSION switch to 100; set the RF ATTENUATOR dB switch to 10; increase the signal generator output level to 0 dBm; adjust the IF GAIN control until the peak of the right sideband pip is coincident with the graticule LOG scale 20 dB horizontal line. Tune the signal generator across its band 1 capability (10-450 MHz) noting the maximum pip peak rise and fall with respect to the 20 dB reference line.	h. Maximum pip peak deviation from the 20 dB reference line shall not exceed ±3.5 dB (±0.35 divisions).
		i. Tune the signal generator to the frequency at which the pip rose the maximum above the LOG scale 20 dB reference line and adjust its output level to -55 dBm. Repeat step 10b. Adjust the TUNING control to position the signal pip at the graticule f_0 vertical line. . Repeat step 10d and f.	Same as 10f.
		j. Repeat step 10i, tuning the signal generator to the frequency at which the pip fell (rather than rose) the maximum with respect to the LOG scale 20 dB reference line.	Same as 10f.
		k. Disconnect the signal generator. Set the TUNING control to an indication of 0.8 and repeat step 10d. Tune an HP-612A signal generator for a cw output of -55 dBm at 800 MHz. Connect the equipment as illustrated in figure 4-1. Repeat step 10f.	k. Same as 10f.
		l. Repeat step 10g. Set the FREQUENCY DISPERSION switch to 100 and disconnect the signal generator.	
		m. Tune an HP-8690B/8699B sweep generator (set for manual tuning between 0.45 and 1.00 GHz) to 800 MHz and adjust for minimum cw output level.	
		n. Connect the equipment as illustrated in figure 4-2A. Increase the sweep generator output level until the peak of the signal pip is coincident with the graticule LOG scale 20 dB horizontal line. NOTE If, when set for minimum output level, the peak of the signal pip is above the LOG scale 20 dB line, insert calibrated padding between the sweep generator and the magic tee or power divider.	
		o. Tune the sweep generator between its preset frequency limits and note the maximum pip peak rise (and fall) with respect to the LOG scale 20 dB reference line; also note the frequencies at which these maxima occur.	o. Same as 10h.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
10 Cont		p. Disconnect the equipment from the SIGNAL INPUT .01-12.4 GHz jack. Repeat step 10i, using the HP-612A signal generator.	p. Same as 10f.
		q. Repeat step 10j.	q. Same as 10f.
		r. Disconnect the signal generator. Set the TUNING control for an indication of 2.4. Repeat step 10d. Tune an HP-8614A signal generator for a cw output of -55 dBm at 2.40 GHz. Connect the equipment as illustrated in figure 4-1. Repeat step 10f.	r. Same as 10f.
		s. Repeat step 10g., set the FREQUENCY DISPERSION switch to 300 and disconnect the signal generator.	
		t. Tune the HP-8690B/8699B sweep generator (set for manual tuning between 1.00 and 2.00 GHz) to 2.00 GHz and adjust for minimum cw output level. Repeat steps 10n and 10o.	t. Maximum pip peak deviation from the 20 dB reference line shall not exceed ±3 dB (±0.3 divisions).
		u. Tune the HP-8690B/8699B sweep generator (set for manual tuning between 2.00 and 3.50 GHz) to 2.00 GHz and adjust for minimum cw output level. Repeat steps 10n and 10o.	u. Same as 10t.
		v. Disconnect the equipment from the SIGNAL INPUT .01-12.4 GHz jack. Repeat step 10i, using an HP-8614A or HP-8616A signal generator, as required.	v. Same as 10f.
		w. Repeat step 10j.	w. Same as 10f.
		x. Disconnect the signal generator. Set the RANGE switch to 3-6 GHz; adjust the TUNING control to obtain a pointer indication of 4.5 and repeat step 10d. Tune an HP-618C signal generator for a cw output of -55 dBm at 4.00 GHz. Connect the equipment as illustrated in figure 4-1. Repeat step 10f.	x. Same as 10f.
		y. Repeat step 10g., set the FREQUENCY DISPERSION switch to 300 and disconnect the signal generator.	
		z. Tune the HP-8690B/8699B sweep generator (set for manual tuning between 3.00 and 4.00 GHz) to 4.00 GHz and adjust for minimum cw output level. Repeat steps 10n and 10o.	z. Same as 10t.
		aa. Tune an HP-8690B/8693A sweep generator (set for manual tuning between 4.00 and 6.00 GHz) to 4.00 GHz and adjust for minimum cw output level. Repeat steps 10p and 10o.	aa. Same as 10t.
		ab. Disconnect the equipment from the SIGNAL INPUT .01-12.4 GHz jack. Repeat step 10i., using an HP-8616A or HP-618C signal generator as required.	ab. Same as 10f.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
10 Cont		ac. Repeat step 10j.	ac. Same as 10f.
		ad. Disconnect the signal generator. Set the RANGE switch to 4.5-10 GHz, adjust the TUNING control for an indication of 6 and repeat step 10d. Tune an HP-620B signal generator for a cw output of -50 dBm at 7.25 GHz. Connect the equipment as illustrated in figure 4-1. Repeat step 10f.	ad. Signal generator output level does not exceed -60 dBm.
		ae. Repeat step 10g. Set the FREQUENCY DISPERSION switch to 300 and disconnect the signal generator. Tune the HP-8690B/8693A sweep generator (set for manual tuning between 4.50 and 7.30 GHz) to 7.25 GHz and adjust for minimum cw output level. Repeat step 10n, using the equipment setup of figure 4-2B, and 10o.	ae. Maximum pip peak deviation from the 20 dB reference line shall not exceed ±4.5 dB (±0.45 divisions).
		af. Adjust the TUNING control for an indication of 8.5. Tune an HP-8690B/HO1-8694B sweep generator (set for manual tuning between 7.20 and 10.00 GHz) to 7.25 GHz and adjust for minimum cw output level. Repeat steps 10n; the equipment setup of figure 4-2C, and 10o. **Note** As the sweep generator is tuned up frequency, a second (image response) pip will enter the display from the left at a frequency of approximately 9 GHz. Disregard this pip.	af. Same as 10ae.
		ag. Disconnect the equipment from the SIGNAL INPUT .01-12.4 GHz jack. Repeat step 10i, using a signal generator adjusted for a cw output level of -50 dBm, as required.	ag. Same as 10ad.
		ah. Repeat step 10j.	ah. Same as 10ad.
		ai. Disconnect the signal generator. Set the RANGE switch to 9-12.4 GHz, adjust the TUNING control for an indication of 10.5 and repeat step 10d. Tune a signal generator for a cw output of -45 dBm at 10.5 GHz. Connect the equipment as illustrated in figure 4-1 and repeat step 10f.	ai. Signal generator output level does not exceed -55 dBm.
		aj. Repeat step 10g. Set the FREQUENCY DISPERSION switch to 300 and disconnect the signal generator. Tune an HP-8690B/HO1-8694B sweep generator (set for manual tuning between 9.00 and 11.00 GHz) to 10.5 GHz and adjust for minimum cw output level. Repeat step 10n, using the equipment setup of figure 4-2C, and 10o. **Note** As the sweep generator is tuned down frequency, a second (image response pip will enter the display from the right at a frequency of	aj. Maximum pip peak deviation from the 20 dB reference line shall not exceed ±3.5 dB (±0.35 divisions).

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
10 Cont		approximately 9.5 GHz. Disregard this pip.	
		ak. Adjust the TUNING control for an indication of 10.9; tune the HP-8690B/HO1-8694B (set for manual tuning between 10.00 and 12.40 GHz) to 10.50 GHz and adjust for minimum output level. Repeat step 10n, using the equipment setup of figure 4-2C and 10o.	ak. Same as 10aj.
		al. Disconnect the equipment from the SIGNAL INPUT .01-12.4 GHz jack. Repeat step 10i using an HP-626A signal generator adjusted for a cw output level of -45 dBm, as required.	al. Same as 10ai.
		am. Repeat step 10j.	am. Same as 10ai.
		Note Complete the following checks of step 10 only for those units utilizing waveguide mixers.	
		an. Disconnect the signal generator. Set the RANGE switch to 12.4-15.5 GHz.	
		ao. Adjust the TUNING control for an indication of 12.4, repeat step 10d, and tune an HP-626A signal generator for a cw output of -65 dBm at 12.4 GHz. Connect the equipment as illustrated in figure 4-3, and repeat step 10f.	ao. Signal generator output level does not exceed -75 dBm.
		ap. Repeat step 10ao with both the TUNING control and signal generator adjusted, in sequence, for frequencies of 14 and 15.5 GHz.	ap. Same as 10ao.
		aq. Disconnect the signal generator. Set the RANGE switch to 15-21 GHz.	
		ar. Adjust the TUNING control for an indication of 15, repeat step 10d and tune an HP-628A signal generator for a cw output of -60 dBm at 15 GHz. Connect the equipment as illustrated in figure 4-3 and repeat step 10f.	ar. Signal generator output level does not exceed -70 dBm.
		as. Repeat step 10ar with both the TUNING control and signal generator adjusted, in sequence, to frequencies of 17, 19 and 21 GHz.	as. Same as 10ar.
		at. Disconnect the signal generator. Set the RANGE switch to 20-26.5 GHz.	
		au. Adjust the TUNING control for an indication of 20, repeat step 10d and tune an HP-626A signal generator for a +10 dBm cw output at a frequency one-half that of the RF-3000 setting. Adjust the HP-938A frequency doubler for an output of -75 dBm. Connect the equipment as illustrated in figure 4-4 and repeat step 10f.	au. Frequency doubler output level shall not exceed -85 dBm.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont)

STEP	PURPOSE	PROCEDURE	ACCEPTABLE INDICATION
10 Cont		av. Repeat step 10av with the TUNING control adjusted, in sequence, to obtain pointer indications of 22, 24 and 26.5.	av. Same as 10au.
		aw. Disconnect the equipment. Set the RANGE switch to 26.5-31 GHz.	
		ax. Adjust the TUNING control for an indication of 26.5, repeat step 10d and tune an HP-626A signal generator for a +10 dBm cw output at a frequency equal to one-half that to which the RF-3000 is tuned. Adjust the HP-940A frequency doubler for a -70 dbm output. Connect the equipment as illustrated in figure 4-4 and repeat step 10f. Release the PHASE LOCK pushbutton switch.	ax. Frequency doubler output level shall not exceed -80 dbm.
		ay. Repeat step 10ax with the TUNING control adjusted in sequence, to obtain pointer indications of 28 and 31.	ay. Same as 10ax.
		az. Disconnect the equipment. Set the RANGE switch to 30-40 GHz.	
		ba. Adjust the TUNING control to obtain a pointer indication of 30, repeat step 10d and tune an HP-628A signal generator for a +10 dbm cw output at a frequency equal to one-half that to which the RF-3000 is tuned. Adjust the HP-940A frequency doubler for a -65 dBm. output. Connect the equipment as illustrated in figure 4-4 and repeat step 10f.	ba. Frequency doubler output level shall not exceed -75 dBm.
		bb. Repeat step ba with the TUNING control adjusted in sequence for indications of 33, 36, 38, and 40.	bb. Same as 10ba.

Note

Using the 100 kHz bandwidth instead of the 1 kHz bandwidth in the actual sensitivity measurement removes the inaccuracies caused by the frequency instability of the signal generators employed in the test. Most microwave signal generators have incidental FMs of up to 50 kHz, while the SPA-3000 (when phase locked) has resolving capabilities of 1 kHz up to 40 GHz. Therefore, when the 100 kHz bandwidth is employed, a correction factor must be added to the signal generator output level in order to obtain the true sensitivity of the SPA-3000 at a bandwidth of 1 kHz. This correction factor is the translation of the sensitivity measurement at a bandwidth of 100 kHz to that for a bandwidth of 1 kHz.

Since the incidental FM of the RF-3000 first local oscillator is a maximum of 100 Hz p-p (fundamantal output-phase locked), the incidental FM of the seventh harmonic is then 700 Hz. Therefore the SPA-3000 can resolve 1 kHz over its entire frequency range.

The sensitivity measurement obtained using a bandwidth of 100 kHz can be translated to the equivalent sensitivity at a bandwidth of 1 kHz (the minimum resolution bandwidth of the SPA-3000) by adding the correction factor calculated from the equation

$$\text{Bandwidth correction factor} = 10 \log \frac{100 \text{ kHz (measurement BW)}}{1 \text{ kHz (minimum resolution BW)}}$$

$$= 20 \text{ dB}$$

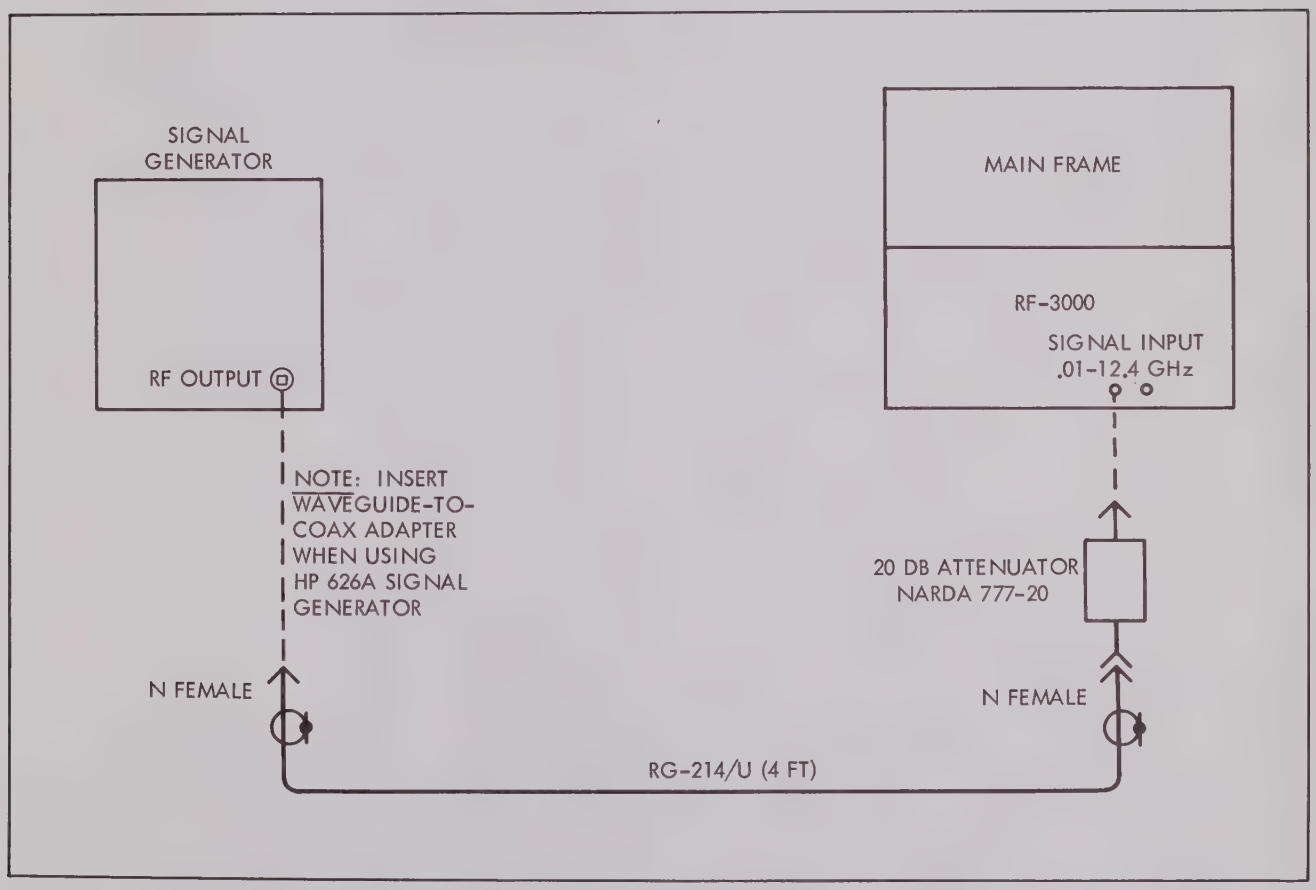


Figure 4-1. Minimum Performance Standards Checks, Equipment Setup No. 1

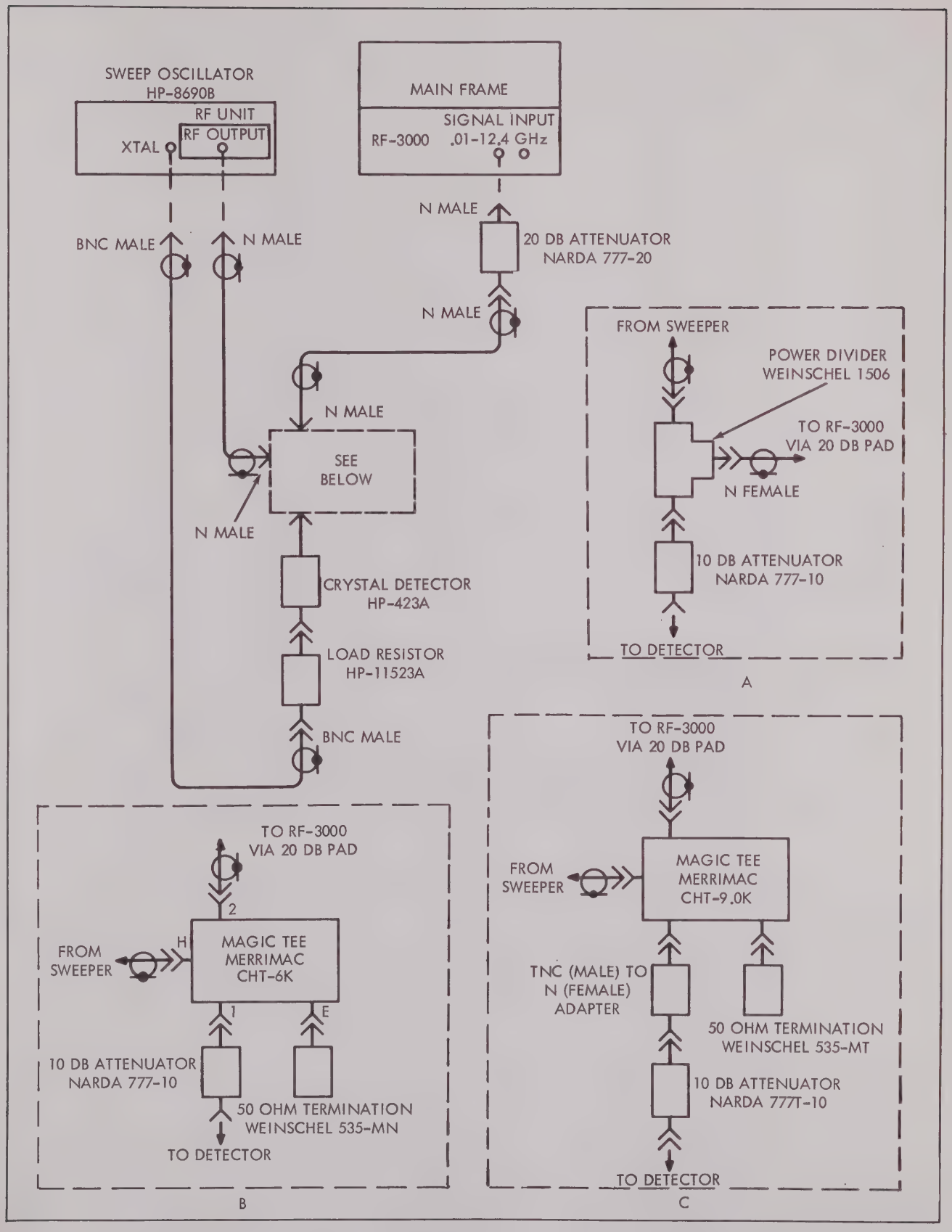
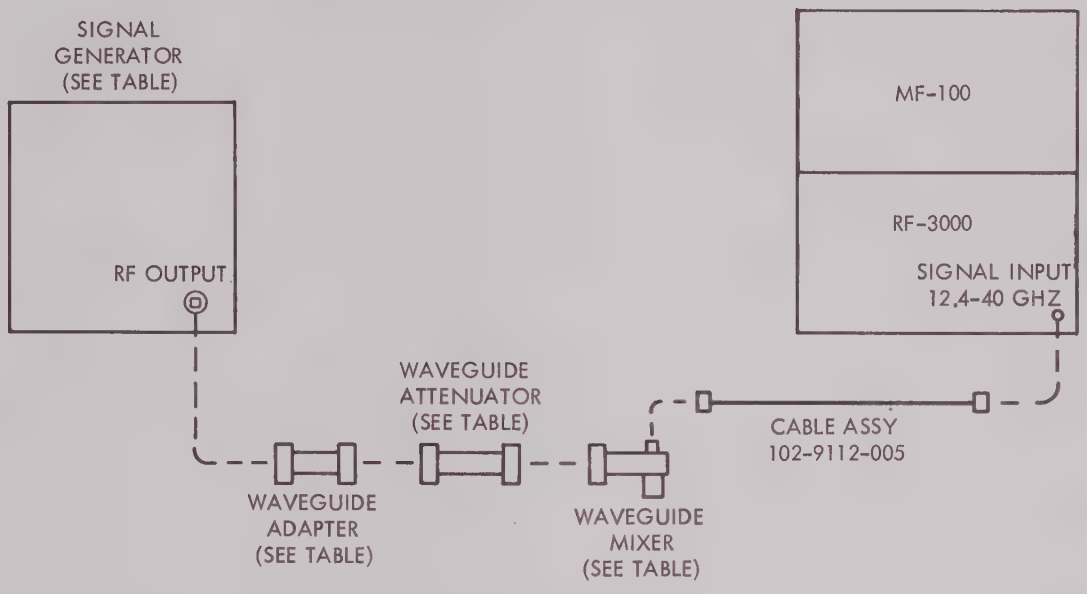
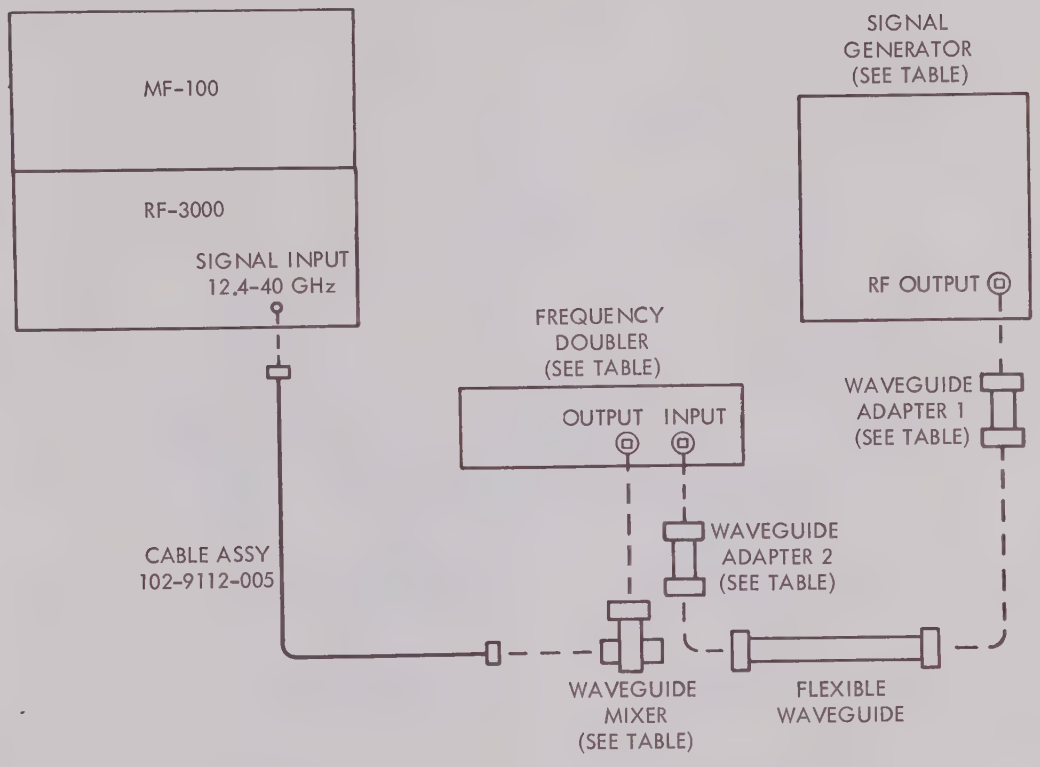


Figure 4-2. Minimum Performance Standards Checks, Equipment Setup No. 2



RANGE SWITCH SETTING	TUNING CONTROL SETTING	SIGNAL GENERATOR	WAVEGUIDE ADAPTER	WAVEGUIDE ATTENUATOR	WAVEGUIDE MIXER
12.4-15.5 GHz	12.4-15 GHz	HP 626A	HP MP292B	47U2	K_U-3000
15-21 GHz	15-18 GHz	HP 628A	HP NP292A	47U2	K_U-3000
15-21 GHz	18-21 GHz	HP 628A	HP NK292A	---	K-3000

Figure 4-3. Minimum Performance Standards Checks, Equipment Setup No. 3



RANGE SWITCH SETTING	SIGNAL GENERATOR	FREQUENCY DOUBLER	WAVEGUIDE ADAPTER		WAVEGUIDE MIXER
			1	2	
20-26.5 GHz	HP 626A	HP 938A	HP MX292B	HP MX292A	K-3000
26.5-31 GHz	HP 626A	HP 940A	HP MP292B	HP NP292B	K_a-3000
30-40 GHz	HP 628A	HP 940A	HP NP292A	HP NP292A	K_a-3000

Figure 4-4. Minimum Performance Standards Checks, Equipment Setup No. 4

4-7. COMPONENT LOCATIONS.

4-8. The location of the major assemblies within the RF-3000 are illustrated in figure 4-5 and 4-6. To gain access to these assemblies, remove the top, bottom and side covers from the equipment chassis.

4-9. POWER SUPPLY TROUBLE LOCALIZATION.

4-10. Improper operation of the RF-3000 may be due to a malfunction within the power supplies. To ascertain that these supplies are operating properly, or to localize a malfunction, proceed as directed in table 4-3.

WARNING

VOLTAGES DANGEROUS TO HUMAN LIFE EXIST WITHIN THE RF-3000. OBSERVE EXTREME CAUTION AT ALL TIMES WHEN MEASURING POWER SUPPLY VOLTAGES.

REMOVE SYSTEM POWER FROM THE RF-3000 BEFORE CONNECTING OR DISCONNECTING VOLTMETER PROBES TO EITHER HELIX OR ANODE POWER SUPPLY TEST POINTS. REMEMBER THAT A ONE (1) MINUTE DELAY PERIOD MUST EXPIRE BEFORE OPERATING POWER IS REAPPLIED AFTER THE SYSTEM IS ENERGIZED.

CAUTION

Always release the SYSTEM POWER pushbutton switch before removing or replacing any of the plug-in printed circuit boards, particularly when mounting them onto the service extender board during checkout procedures.

4-11. Before applying power to the equipment, remove line fuses F1 and F2 from their rear panel fuseholders. Check the fuses for proper rating (per the setting of 115/230 volt switch S11 and the available line power) and continuity. If the fuses are of proper rating and are continuous, replace them and proceed to table 4-3. If the fuses are not continuous, locate and repair the fault before replacing the fuses and checking the supplies.

Note

When the bottom cover is removed, high voltage interlock P7 is disconnected, preventing the helix and anode power supplies from being energized. This interlock can be overridden by fabricating a short jumper and inserting the ends into the female contacts of J15.

4-12. SYMPTOMATIC TROUBLESHOOTING PROCEDURE.

4-13. The selectable tuning bands and auxiliary functions (such as phase lock and RF markers) enables the technician to isolate a malfunction to an individual group of circuits and/or components by symptomatic troubleshooting procedures. Once the malfunction has been isolated to the particular circuit/component grouping, systematic trouble localization procedures will lead the technician to the defective assembly or component. Table 4-4 is a symptomatic troubleshooting guide which lists the possible causes of a given symptom and references the appropriate remedial action required to restore the RF-3000 to proper operating condition.

4-14. CHECKOUT AND ALIGNMENT PROCEDURES.

4-15. The checkout and alignment procedures for the components and circuits within the RF-3000 are detailed in paragraphs 4-16 through 4-62.

4-16. COAXIAL RELAYS A1K1, A1K3, A1K2, A1K4, AND A1K5. Initially, disconnect all cables and components from the relay under test, remove line power from the RF-3000 and then proceed as follows:

a. Set the RF-3000 control switches as indicated below:

1. A1K1 and A1K3; RANGE switch to .01-3.5 GHz.

2. A1K2 and A1K4; RANGE switch to 9-12.4 GHz.

3. A1K5; PHASE LOCK pushbutton switch released.

b. Using a Simpson 260 VOM, measure the resistance between the inner conductors of the common (C) and normally-closed (NC) connectors; it should be zero ohms. Measure the resistance between the inner conductors of the common (C) and normally-open (NO) connectors; it should be infinite.

c. Measure the resistance between the inner

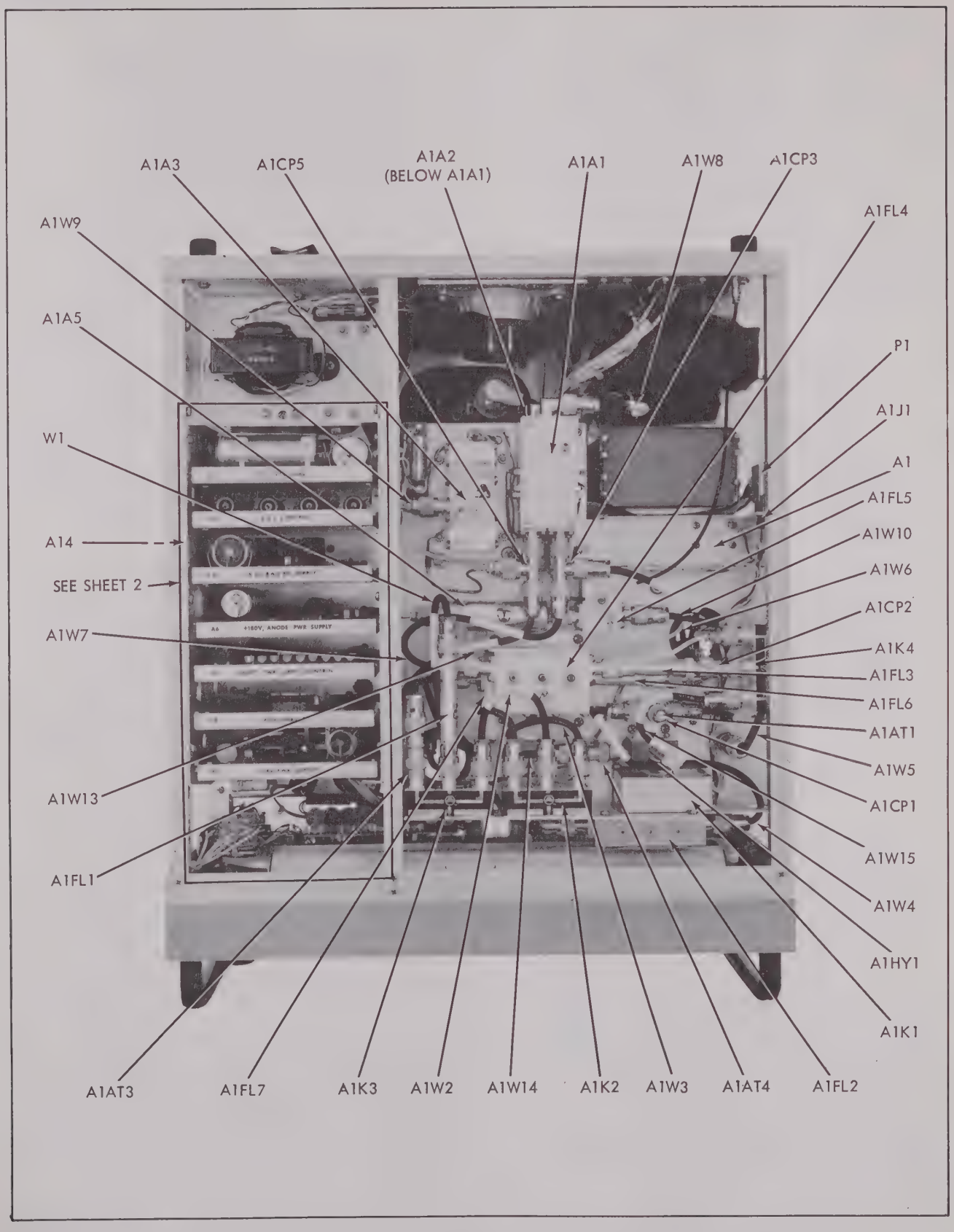


Figure 4-5. RF-3000, Top View (Sheet 1 of 2)

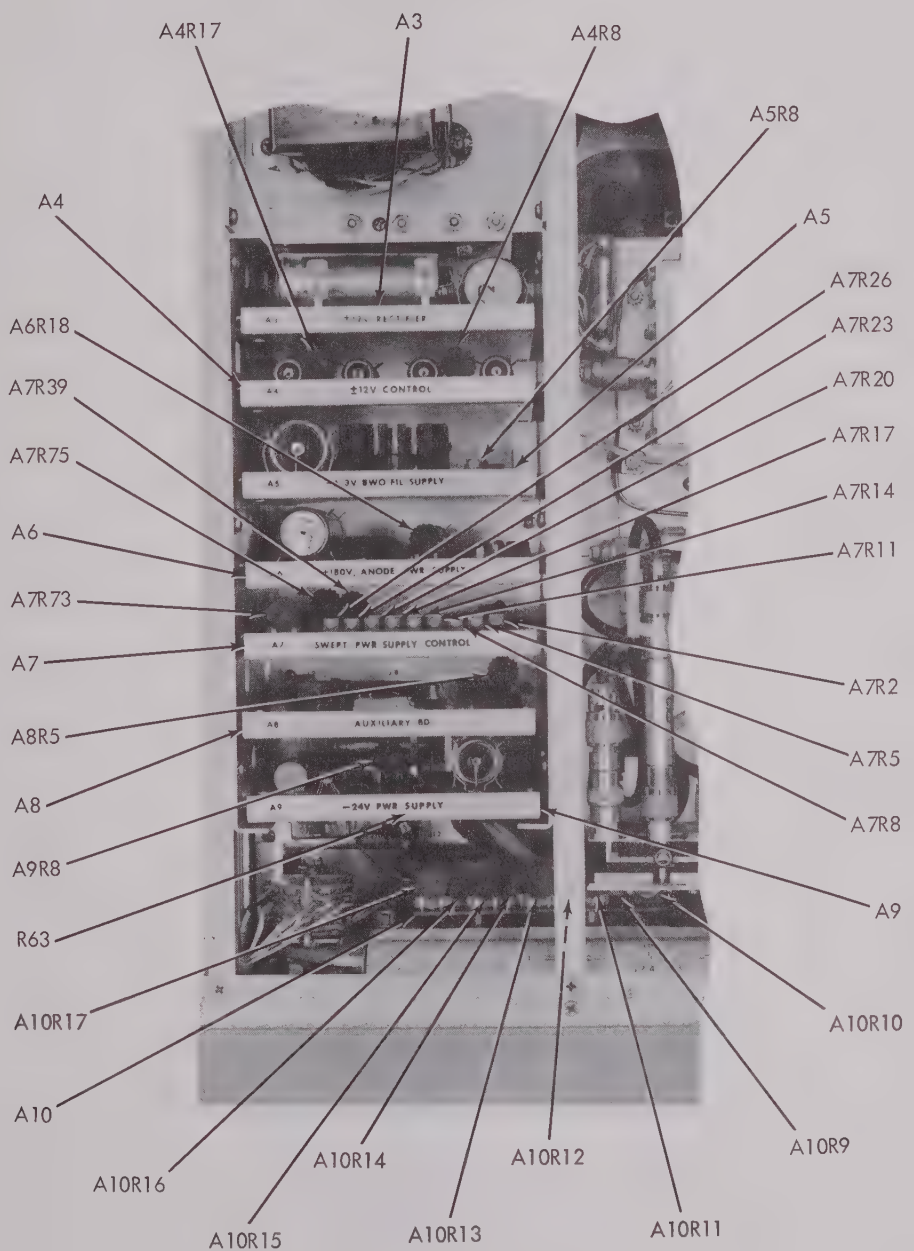


Figure 4-5. RF-3000, Top View (Sheet 2 of 2)

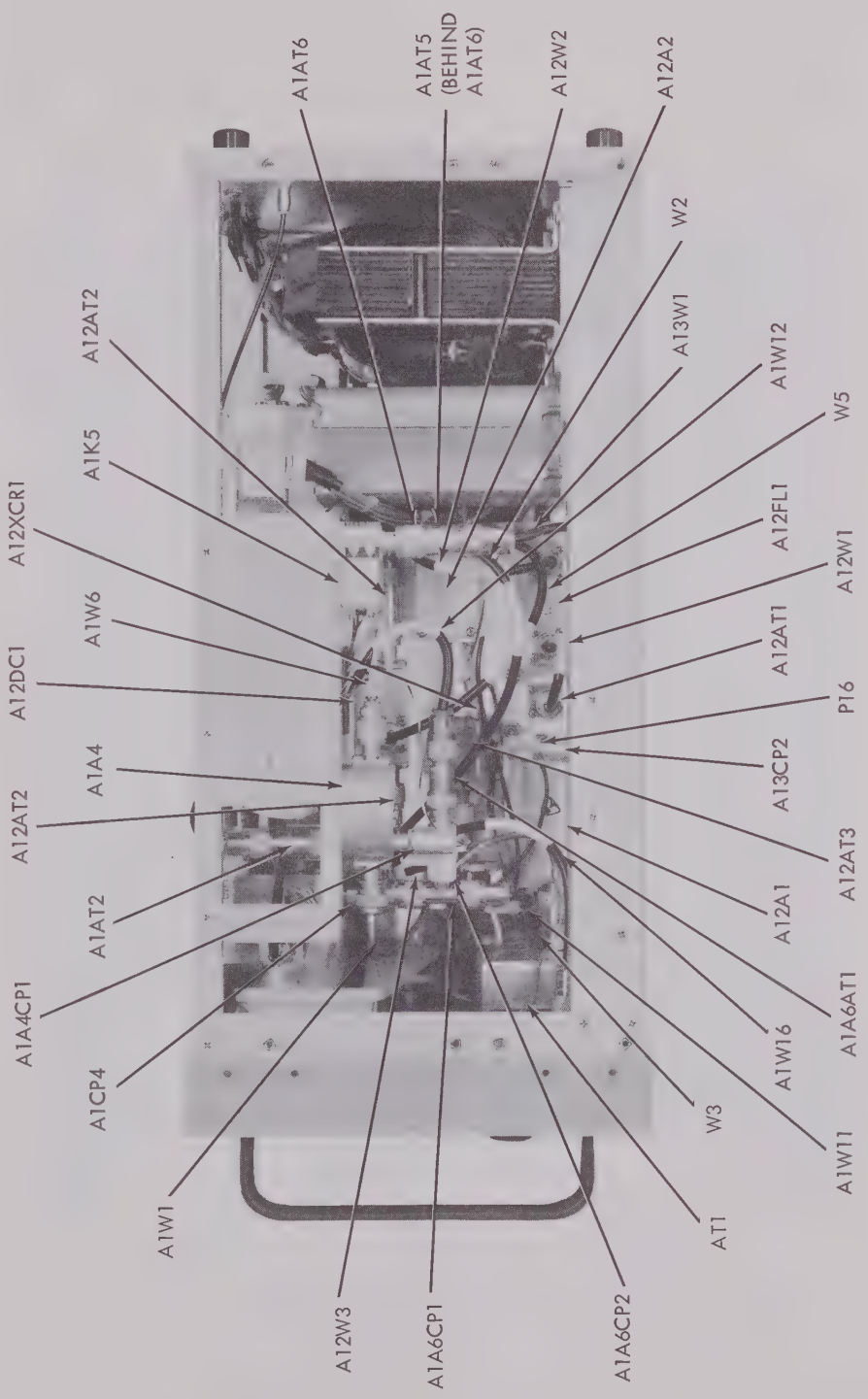


Figure 4-6. RF-3000, Right Side View

TABLE 4-3. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE

STEP		PROCEDURE	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
MAJOR	MINOR				
1		Connect the INPUT jack of a Singer-Ballantine 3570/3572 Digital DC Measuring System to the RF-3000 rear panel +12V test point; connect the common lead to the GRD test point. Couple the vertical input terminals of an HP 130C oscilloscope (AC coupled; 200μV/CM) across the same test points.	+12 ±0.010 volts; ripple is 700μV p-p or less.	Proceed to major step 2.	Adjust potentiometer A4R8 to obtain an output level of +12.00 volts. If this output level cannot be attained by adjustment of the control, proceed to minor step 1.
	1	Connect the "+" lead of a Simpson 260 VOM (set to the 50 VAC range) to J3-5; connect the "common" lead to J3-4.	15 volts rms (nominal).	Proceed to minor step 2.	Replace transformer T1 and then repeat major step 1.
	2	Release the SYSTEM POWER pushbutton switch, withdraw ±12V rectifier A3 from jack J3 and check fuse A3F1 for continuity.	Fuse is continuous.	Replace fuse, replace ±12V rectifier A3 and proceed to minor step 3.	a. Withdraw ±12V control A4 from J4 and measure the resistance between J4-2 and J4-9; normal value is approximately 170 ohms. If this indication is obtained, proceed to step b. If a dead short is indicated, check the +12 volt distribution lines for its location, repair the fault, install a replacement fuse, replace ±12V rectifier A3 and ±12V control A4 and repeat major step 1. b. Withdraw auxiliary control A8 from jack J8 and measure the resistance between J8-12 and J8-1; normal value is approximately 1000 ohms. If this indication is obtained, replace auxiliary control A8 and proceed to minor step 3. If a dead short is indicated, check the +11.3 volt distribution line for its location, repair the fault, install a replacement fuse, replace ±12V rectifier A3 and A8 and repeat major step 1.
	3	Depress the SYSTEM POWER pushbutton switch, connect the "+" lead of the VOM (set to the +50 VDC range) to J3-7; connect the "common" lead to J3-2.	+19 volts (nominal).	Check Q1 (refer to table 4-7), A4Q1 through A4Q4 (refer to table 4-12) and associated circuitry. After the necessary repairs have been effected, replace ±12V control A4 and repeat major step 1.	Check A3CR1 through A3CR4 and associated circuitry. After the necessary repairs have been effected, replace ±12V rectifier A3 and repeat major step 1.

TABLE 4-3. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

STEP		PROCEDURE	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
MAJOR	MINOR				
2		Connect the INPUT jack of the Singer-Ballantine 3570/3572 to J8-12; connect the common lead to J8-1. Couple the oscilloscope across the same test points.	+11.0 ±0.010 volts; ripple is 20μV p-p or less.	Proceed to major step 3.	Check auxiliary control transistors A8Q11 through A8Q13 (refer to table 4-16) and associated circuitry.
3		Connect the INPUT jack of the Singer-Ballantine 3570/3572 to the RF-3000 rear panel -12V test point; connect the common lead to the GRD test point. Couple the oscilloscope across the same test points.	-12 ±0.010 volts; ripple is 700μV p-p or less.	Proceed to major step 4.	Adjust potentiometer A4R17 to obtain an output level of -12.00 volts. If this output level cannot be obtained by adjustment of the control, proceed to minor step 4.
	4	Connect the "+" lead of a Simpson 260 VOM (set to the 50 VAC range) to J3-15; connect the "common" lead to J3-14.	15 volts rms (nominal).	Proceed to minor step 5.	Replace transformer T1 and then repeat major steps 1 and 3.
	5	Release the SYSTEM POWER pushbutton switch, withdraw ±12V rectifier A3 from J3 and check fuse A3F2 for continuity.	Fuse is continuous.	Replace fuse, replace ±12V rectifier A3 and proceed to minor step 6.	Withdraw ±12V control A4 from J4 and measure the resistance between J4-18 and J4-9; normal value is approximately 800 ohms. If a dead short is indicated, check the -12 volt distribution lines for its location, repair the fault, install a replacement fuse, replace ±12V rectifier A3 and ±12V control A4 and repeat major step 3.
	6	Depress the SYSTEM POWER pushbutton switch, connect the "+" lead of the VOM (set to the -50 VDC range) to J3-17; connect the "common" lead to J3-12.	-19 volts (nominal).	Check transistor Q2 (refer to table 4-7). ±12V control transistors A4Q5 through A4Q8 (refer to table 4-12) and associated circuitry. After the necessary repairs have been effected, replace ±12V control A4 and repeat major step 3.	Check ±12V rectifier diodes A3CR5 through A3CR8 and associated circuitry. After the necessary repairs have been effected, replace ±12V rectifier A3 and repeat major step 3.
4		Connect the INPUT jack of the Singer-Ballantine 3570/3572 to J9-13; connect the common lead to J9-16. Couple the oscilloscope across the same test points.	-24 ±0.030 volts; ripple is 50μV p-p or less.	Proceed to major step 5.	Adjust potentiometer A9R8 to obtain an output level of -24.00 volts. If this output level cannot be attained by adjustment of the control, proceed to minor step 7.

TABLE 4-3. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

STEP MAJOR	STEP MINOR	PROCEDURE	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
4 (cont'd)	7	Connect the "+" lead of a Simpson 260 VOM (set to the 50VAC range) to T3-5; connect the "common" lead to T3-6.	30 volts rms (nominal).	Proceed to minor step 8.	Replace transformer T3 and repeat major step 4.
	8	Release the SYSTEM POWER pushbutton switch and check fuse F3 for continuity.	Fuse is continuous.	Replace fuse and proceed to minor step 10.	Withdraw -24V power supply A9 from J9 and measure the resistance between J9-4 and J9-3 (connecting the "ohms" lead of the VOM to J9-4) for all settings of the RANGE switch: the normal values are infinity (bands 1, 3 and 4) and approximately 100 ohms for bands 2 and 5 through 9. If these values are indicated, replace -24V power supply A9 and proceed to minor step 9. If a dead short is indicated, check the -26 volt distribution lines for its location, repair the fault, install a replacement fuse, replace -24V power supply A9 and repeat major step 4.
	9	With -24V power supply A9 still withdrawn from J9, measure the resistance between J9-13 and J9-16.	Approximately 5000 ohms.	Replace -24V power supply A9 and proceed to minor step 10.	Check the -24 volt distribution lines for the location of a short circuit, repair the fault, replace A9 and repeat major step 4.
	10	Replace A9 into J9. Connect the "+" lead of the VOM (set to the +50 VDC range) to J9-3; connect the "common" lead to J9-16. Depress the SYSTEM POWER pushbutton switch.	-26 volts (nominal).	Check -24V power supply transistors A9Q1, A9Q2, A9MC1 (refer to table 4-17) and associated circuitry. After the necessary repairs have been effected, replace -24V power supply A9 and repeat major step 4.	Check -24V power supply diodes A9CR1 through A9CR4 and associated circuitry. After the necessary repairs have been effected, replace -24V power supply A9 and repeat major step 4.
5		Connect the INPUT jack of the Singer-Ballantine 3570/3572 to J9-18; connect the common line to J9-16. Couple the oscilloscope across the same test points.	-12 ±0.24 volts; ripple is 40μV p-p or less.	Proceed to major step 6.	Proceed to minor step 11.
	11	Release the SYSTEM POWER pushbutton switch, withdraw A9 from J9 and measure the resistance between J9-18 and J9-16.	Approximately 100 kohms.	Replace -24V power supply A9 and depress the SYSTEM POWER pushbutton switch. Proceed to major step 6.	Check the -12 volt (second LO) distribution line for the location of a short circuit, repair the fault and replace -24V power supply A9. Depress the SYSTEM POWER pushbutton switch and proceed to major step 6.

TABLE 4-3. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

STEP MAJOR	STEP MINOR	PROCEDURE	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
6		Connect the INPUT jack of the Singer-Ballantine 3570/3572 to the RF-3000 rear panel -6.3V test point; connect the common lead to the GRD test point. Couple the oscilloscope (set for a vertical sensitivity of 1mV/CM AC) across the same test points.	-6.1 ±0.010 volts; ripple is 2 mv p-p or less.	Proceed to major step 7.	Adjust potentiometer A5R8 to obtain an output level of -6.1 volts. If this output level cannot be attained by adjustment of this control, proceed to minor step 12.
	12	Connect the "+" lead of a Simpson 260 VOM (set to the 50 VAC range) to J5-15; connect the "common" lead to J5-17.	9 volts rms (nominal).	Proceed to minor step 13.	Replace transformer T1 and repeat major steps 1, 3 and 6.
	13	Release the SYSTEM POWER push-button switch, withdraw BWO filament power supply A5 from J5 and check fuse A5F1 for continuity.	Fuse is continuous.	Replace the fuse, replace BWO filament power supply A5 and proceed to minor step 14.	Measure the resistance between J5-1 and J5-18. If a short circuit is indicated, check the -6.1 volt distribution line for its location, repair the cause of the short circuit, replace the fuse and BWO filament power supply A5 and repeat major step 6.
	14	Depress the SYSTEM POWER push-button switch and connect the "+" lead of the VOM to A3F1.	+9 volts (nominal).	Check BWO filament power supply transistors A5Q1 through A5Q4 (refer to table 4-13) and associated circuitry. Repeat major step 6 after the necessary repairs have been effected.	Check BWO filament power supply diodes A5CR1 through A5CR4 and associated circuitry. Repeat major step 6 after the necessary repairs have been effected.
7		Connect the "+" lead of a Simpson VOM (set to the +1000 VDC range) to J6-13; connect the "common" lead to J6-1.	+300 volts (nominal).	Proceed to major step 8.	Proceed to minor step 15.
	15	Connect the "+" lead of the VOM (set to the 1000 VAC range) to J6-7; connect the "common" lead to J6-9.	450 volts rms (nominal).	Check +180V/BWO anode supply diode A6CR1, A6CR2 and associated circuitry. After the necessary repairs have been effected, repeat major step 7.	Replace transformer T2 and repeat major step 7.

TABLE 4-3. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

STEP		PROCEDURE	NORMAL INDICATION	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
MAJOR	MINOR				
8		Connect the "+" lead of the VOM (set to the +250 VDC range) to the RF-3000 rear panel +180V test point; connect the "common" lead to the GRD test point. Couple the oscilloscope across the same test points.	+180 ±18 volts; ripple is 10 mV p-p or less.	Proceed to major step 9.	Check +180V/BWO anode supply diodes A6CR3 and associated circuitry. Repeat major step 8 after the necessary repairs have been effected.
9		Connect the "+" lead of the VOM (still set to the +1000 VDC range) to the RF-3000 rear panel ANODE test point; connect the "common" lead to the GRD test point. Couple the oscilloscope across the same test points. Depress the LO ENABLE pushbutton switch.	Determined by the data presented on the nameplate of V3; ripple is 5 mV p-p or less.	Release the LO ENABLE pushbutton switch and proceed to major step 10.	a. If output level is 0 volts, ascertain whether it is due to a short circuit (to ground) of the anode line or too low a helix voltage. If the former, find and repair the fault; if the latter, adjust setting of TUNING and or FREQUENCY DISPERSION controls. b. Adjust potentiometer A9R18 to obtain the proper output voltage. If proper level cannot be obtained, check +180V/BWO anode supply transistors A6Q1 through A6Q9 (refer to table 4-14). Repeat major step 9 after effecting the necessary repairs.
10		With the SYSTEM POWER pushbutton switch released, connect the "5000V" lead of the VOM (set to +DC) to V2-3; connect the "common" lead to chassis ground. With the RANGE switch set to .01-3.5 GHz and the TUNING control adjusted to obtain a pointer indication of .01, depress the kHz/DIV pushbutton switch. Depress the SYSTEM POWER pushbutton switch and, after a two minute delay, slowly rotate the TUNING control clockwise, noting the VOM indication, until a pointer indication of 3.5 is obtained.	Helix voltage varies from approximately +225 (at .01 GHz) to +1100 (at 3.5 GHz) volts as a function of TUNING control rotation.	Power supplies are operating properly. Release the SYSTEM POWER pushbutton switch.	Release the SYSTEM POWER pushbutton switch and proceed to minor step 16.
	16	With the SYSTEM POWER pushbutton switch released, connect the "5000V" lead of the VOM (set to AC) to T2-8; connect the "common" lead to T2-10. Depress the SYSTEM POWER pushbutton switch and, after a two minute delay, note the VOM indication.	2000 volts rms (nominal).	Check CR1 through CR5. Check V1 and V2 (refer to table 4-7). Check swept power supply control A7 (refer to table 4-15). Check tuning limit control A10 (refer to table 4-18).	Replace transformer T2.

TABLE 4-4. SYMPTOMATIC TROUBLE LOCALIZATION PROCEDURE

STEP	TROUBLE	PROCEDURE	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
1	Bands 1, 3 and 4 inoperative; bands 2 and 5 through 9 operate properly.	Check cables A1W1 and A1W3 through A1W6.	Connect cables between appropriate components.	Fabricate or order new cable. Install replacement cable between appropriate components.
		Check relays A1K1 through A1K4 per paragraph 4-16.	Couple cables and/or components to the appropriate relay connectors.	Replace defective relay.
		Check frequency selective T A1CP1 and 50 ohm termination per paragraph 4-17.	Couple cables to appropriate T connectors.	Install replacement T and/or termination.
		Check mixer diode A1A4CR1 per paragraph 4-20.	Replace diode into system.	Install replacement diode.
		Check attenuator A1AT3 per paragraph 4-24.	Replace attenuator into system.	Install replacement attenuator.
		Check 4 GHz notch filter A1FL2 per paragraph 4-29.	Couple cables to appropriate filter connectors.	Align filter per paragraph 4-29.
2	Band 2 inoperative; bands 1 and 3 through 9 operate properly.	Check cables A1W11 through A1W13.	Connect cables between appropriate components.	Fabricate or order new cable. Install replacement cable between appropriate components.
		Check relays A1K1 and A1K3 per paragraph 4-16.	Couple cables and/or components to the appropriate relay connectors.	Replace defective relay.
		Check mixer diode A1A6CR1 per paragraph 4-20.	Replace diode into system.	Install replacement diode.
		Check mixer diode A1A1CR2 per paragraph 4-22.	Couple A1CP5 to A1A1J2.	Install replacement connector/mixer assembly.
		Check attenuators A1AT3 and A1A6AT1 per paragraph 4-24.	Replace attenuators into system.	Install replacement attenuator.
		Check output of A1A3P1 per paragraph 4-26.	Connect plug A1A3P1.	Align (see paragraph 4-27) or replace defective oscillator.
		Check frequency doubler A1A5 per paragraph 4-28.	Replace doubler into system.	Install replacement doubler.
		Check 2 GHz low-pass filter A1FL6 per paragraph 4-29.	Replace filter into system.	Install replacement filter.

TABLE 4-4. SYMPTOMATIC TROUBLE LOCALIZATION PROCEDURE (Cont'd)

STEP	TROUBLE	PROCEDURE	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
2 (cont'd)		Check 2.08 GHz preselector A1FL7 per paragraph 4-30.	Replace preselector into system.	Align (see paragraph 4-32) or replace defective preselector.
3	Bands 5 and 6 (the latter up to 18 GHz) are inoperative; bands 1 through 4 and 6 (above 18 GHz) through 9 operate properly.	Check the diode in the external Model K_u-3000 waveguide mixer per paragraph 4-21.	Replace diode into mixer.	Install replacement diode.
4	Bands 6 (above 18 GHz) and 7 are inoperative; bands 1 through 6 (up to 18 GHz), 8 and 9 operate properly.	Check the diode in the external Model K-3000 waveguide mixer per paragraph 4-21.	Replace diode into mixer.	Install replacement diode.
5	Bands 8 and 9 inoperative; bands 1 through 7 operate properly.	Check the diode in the external Model K_a-3000 waveguide mixer per paragraph 4-21.	Replace diode into mixer.	Install replacement diode.
6	Bands 5 through 9 inoperative; bands 1 through 4 operate properly.	Check cable 102-9112-005.	Replace cable between mixer and SIGNAL INPUT 12.4-40 GHz jack.	Fabricate or order new cable.
		Check bias T CP2 per paragraph 4-18.	Replace bias T into system.	Install replacement bias T.
		Check cables A1W14 through A1W16.	Connect cables between appropriate components.	Fabricate or order new cable. Install replacement cable between appropriate components.
		Check attenuator A1AT4 per paragraph 4-24.	Replace attenuator into system.	Install replacement attenuator.
		Check relays A1K2 and A1K4 per paragraph 4-16.	Couple cables and/or components to appropriate relay connectors.	Replace defective relay.

TABLE 4-4. SYMPTOMATIC TROUBLE LOCALIZATION PROCEDURE (Cont'd)

STEP	TROUBLE	PROCEDURE	IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
7	Bands 1 and 3 through 9 inoperative; band 2 operates properly.	Check output of A1A3J1 per paragraph 4-26.	Disconnect plug W9P2 from frequency doubler A1A5.	Align (refer to paragraph 4-27) or replace defective oscillator.
		Check cables A1W7, A1W9 and A1W10.	Connect cables between appropriate components.	Fabricate or order new cable. Install replacement cable between appropriate components.
		Check couplers A1CP2 and A1CP3.	Replace couplers into system.	Install replacement coupler.
		Check mixer diode A1A1CR1 per paragraph 4-22.	Connect coaxial coupler A1CP3 to A1A1J1.	Install replacement connector/mixer assembly.
		Check 5 GHz low-pass filter A1FL3 per paragraph 4-29.	Replace filter into system.	Replace defective filter.
		Check 4 GHz preselector A1FL4 per paragraph 4-31.	Replace preselector into system.	Align (refer to paragraph 4-32) or replace defective preselector.
8	All bands inoperative.	Check output at port B of V3 per paragraph 4-34.	-------	Replace V3 per paragraph 4-81.
		Check cables W1, A1W8, output cable (coupling A1A2 to rear panel IF OUTPUT jack) and IF patch cable.	Replace cables between appropriate components.	Fabricate or order new cable. Install replacement cable between appropriate components.
		Check second mixer/160 Mhz preamplifier A1A1 per paragraph 4-38.	Connect coupler and cable to proper jacks.	Align (refer to paragraph 4-40) or replace defective assembly.
		Check 160 MHz band-pass filter/ IF amplifier A1A2 per paragraph 4-38.	Connect cables to proper jacks.	Align (refer to paragraph 4-40) or replace defective assembly.
		Check 8 GHz low-pass filter A1FL1 per paragraph 4-29.	Replace filter into system.	Replace defective filter.
9	Sensitivity specification of an individual band can't be attained.	Adjust mixer diode biasing resistor per paragraph 4-37	-------	-------
10	Frequency accuracy is out of specification.	Calibrate BWO frequency per paragraph 4-35.	-------	-------
11	Phase lock circuitry inoperative.	Check output at port A of V3 per paragraph 4-34.	-------	Replace V3 per paragraph 4-81.

and outer conductors at the C and NC connectors; it should be infinite. For relays A1K1 through A1K4 the resistance between the inner and outer conductors at the NO connector should be zero ohms; for relay A1K5 this resistance should be infinite.

d. Disconnect plug P1 from jack A1J1.

e. Measure the resistance across the coil of the relay (using a polarity to back-bias the shunting transient suppression diode); it should be approximately 125 ohms. Note that if the VOM indicates twice this value, one of the relay coils is open.

f. Set the VOM to the 50 VDC range; connect plug P1 to jack A1J1; couple line power to the RF-3000; and depress the SYSTEM POWER pushbutton switch.

g. Set the RF-3000 control switches as indicated below:

1) A1K1 and A1K3; RANGE switch to 3-6 GHz.

2) A1K2 and A1K4; RANGE switch to 12.4-15.5 GHz, 15-21 GHz, 20-26.5 GHz, 26.5-31 GHz, and 30-40 GHz.

3) A1K5; PHASE LOCK pushbutton depressed.

h. Measure the voltage drop across the relay coil, using the VOM; it should indicate -26 volts at each RANGE switch setting designated. If this voltage is not present, check the power distribution circuitry.

i. Measure the resistance between the inner conductors of the C and NO connectors, it should be zero ohms. Measure the resistance between the inner conductors of the C and NC connectors; it should be infinite.

j. De-energize the RF-3000. If all the indications are obtained, the relay is operating properly. If any desired indication is not obtained, replace the relay under test. When replacement is required, solder a transient suppression diode across the coil of the replacement relay. Couple the appropriate cables and components to the relay.

4-17. FREQUENCY SELECTIVE T A1CP1 AND 50 OHM TERMINATION A1AT1.

a. Mark the connector of the T coupled to the output of the 4 GHz notch filter with a strip of masking tape for reference.

b. Disconnect the cables attached to the straight section of the T.

c. Using a Simpson 260 VOM, measure the resistance between the inner and outer conductors at the tape-marked connector; it should be infinite. Repeat this for the other connector; it should be 50 ohms. If the 50-ohm indication cannot be obtained, disconnect termination A1T1 from the T and measure the resistance between the inner and outer conductors of the connector on the termination; it should be 50 ohms. If it is not, obtain a replacement termination.

d. When the proper indications just described are obtained, replace the T and termination into the RF-3000, noting that the taped connector of the T is connected to the notch filter. If a replacement T is being inserted, note that the port (on the straight section) that exhibits infinite resistance between inner and outer conductors is connected to the notch filter.

4-18. BIAS T CP2.

a. Disconnect plug W16P1 from jack CP2J1 and then disconnect the bias T from coupler CP1.

b. Using a Simpson 260 VOM, measure the resistance between the inner conductors of the connectors; it should be infinite. Measure the resistance between the inner and outer conductor of each connector; it should be infinite.

c. Measure the resistance between the terminal of the feedthrough capacitor and the center conductor of the female connector; it should be zero ohms.

d. If the proper indications are present, replace the T into the RF-3000. If they are not, install a replacement T, soldering the lead from wafer switch S10C-W to the terminal of the feedthrough capacitor.

4-19. MIXER DIODES.

4-20. A1A4CR1, A1A6CR1, and A13CR1.

a. Unscrew the coupler (capacitive coupler A1A4CP1 from radial line mixer A1A4, or coupler A1A6CP2 from T mixer A1A6CP2 or coupler A13CP2 from A13). (See Figure 4-6.)

b. Carefully withdraw the diode and, using an Airborne Instruments 391 crystal tester, check the diode. If the diode is operative, reinstall it (cathode end first); if the diode is faulty, install a replacement diode.

c. Screw the coupler back into place.

4-21. External Waveguide Mixers.

a. Unscrew the knurled crystal holder from the body of the waveguide mixer.

b. Repeat step b of the previous paragraph, using replacement diodes as follows:

Mixer	Diode
Ku-3000	1N4605
K-3000	1N4605
Ka-3000	1N53

c. Return the crystal holder to the body of the waveguide mixer. Check for proper crystal current (refer to paragraph 4-37).

d. When proper crystal current has been obtained, check the SPA-3000 for sensitivity, using the newly-installed crystal.

4-22. A1A1CR1 and A1A1CR2.

Note

The information contained in parentheses refers to diode A1A1CR2 and immediately follows the data applicable to diode A1A1CR1.

CAUTION

Do not check point contact diodes with an ohmmeter; generated voltages can damage the diode.

a. Check the overall sensitivity of the RF-3000 as indicated in paragraph 4-6; check the sensitivity of the I-F section in the Main Frame as indicated in the main Frame manual; check the power output of 1.92 GHz oscillator assembly as indicated in paragraph 4-25. If the overall sensitivity is low with normal I-F (Main Frame) sensitivity and oscillator power output, the crystal mixer is faulty. Replace the faulty crystal mixer by performing the following steps, b through j.

b. Disconnect both T connectors, A1CP3 and A1CP5, by loosening plugs A1CP3P1 and A1CP5P1 from jacks A1A1J1 and A1A1J2, respectively.

c. Disconnect the mixer from 160 MHz bandpass filter/amplifier A1A2 by disconnecting plug A1W8P1 from jack A1A1J3.

d. Loosen and remove the screws that secure both 160 MHz preamplifier A1A1 and 160 MHz amplifier A1A2 to the RF/IF shelf. Remove the cover plate from the top of assembly A1A1.

e. Unsolder the lead connecting the defective connector and mixer assembly to the junction of inductor A1A1L1 and capacitor A1A1C1 (A1A1L2 and A1A1C2).

f. Loosen and remove the four screws that secure the defective connector and mixer assembly to the housing of 160 MHz preamplifier A1A1. Remove the defective connector and mixer assembly and install a replacement assembly.

g. Secure the replacement assembly to assembly using the four screws and washers removed in step f.

h. Using as short a lead length as practical, solder the lead from the replacement assembly to the appropriate point on the printed circuit board.

i. Replace repaired assembly A1A1 on top of the plate covering assembly A1A2; place the cover on top of assembly A1A1 and secure both assemblies to RF/IF shelf A1 using the hardware removed in step d.

j. Connect plug A1W8P1 to jack A1A1J3 and connect T couplers A1CP3 and A1CP5 to their appropriate connectors on assembly A1A1.

4-23. A12CR1.

a. Remove phase lock bracket A12 from the RF-3000 (refer to paragraph 4-77).

b. Loosen and remove the screw that secures 4 to 8 GHz isolator A12AT3 to phase lock bracket A12.

c. Unscrew mixer assembly A12XCR1 from coupler A12A2CP1.

d. Withdraw diode A12CR1 and check the diode using an Airborne Instruments 391 diode tester. Replace faulty diodes with a 1N1132 and install the good diode, anode end first, into coupler A12A2CP1.

e. Screw mixer assembly A12XCR1 coupler A12A2CP1; secure 4 to 8 GHz isolator A12AT3 to phase lock bracket A12, using the hardware removed in step b, and replace phase lock bracket A12 into the RF-3000.

4-24. ATTENUATORS. Check the attenuators with a signal generator or other signal source, a power meter, and a thermistor mount. Measure the insertion loss by subtracting the power meter indications, with the attenuator in the circuit from the power indications obtained when the attenuator is removed from the circuit. The proper values associated with each attenuator are listed below:

Attenuator	Insertion Loss
A1AT2	3 ± 1 dB
A1AT3	3 ± 1 dB
A1AT4	3 ± 1 dB
A1AT5	6 ± 1.5 dB
A1AT6	20 ± 1.5 dB
A1A6AT1	3 ± 1 dB
A12AT1	6 ± 1.5 dB
A12AT2	6 ± 1.5 dB

4-25. 1.92 GHz SECOND LOCAL OSCILLATOR A1A3.

4-26. Checkout.

a. With power removed from the RF-3000, disconnect plug A1W9P2 from jack A1A5J1.

b. Set an HP-432A power meter to the +10 dBm range and interconnect the equipment as illustrated in figure 4-7.

c. Apply power to the RF-3000. After a few minutes warmup, note the power meter indication and determine the oscillator frequency. The power

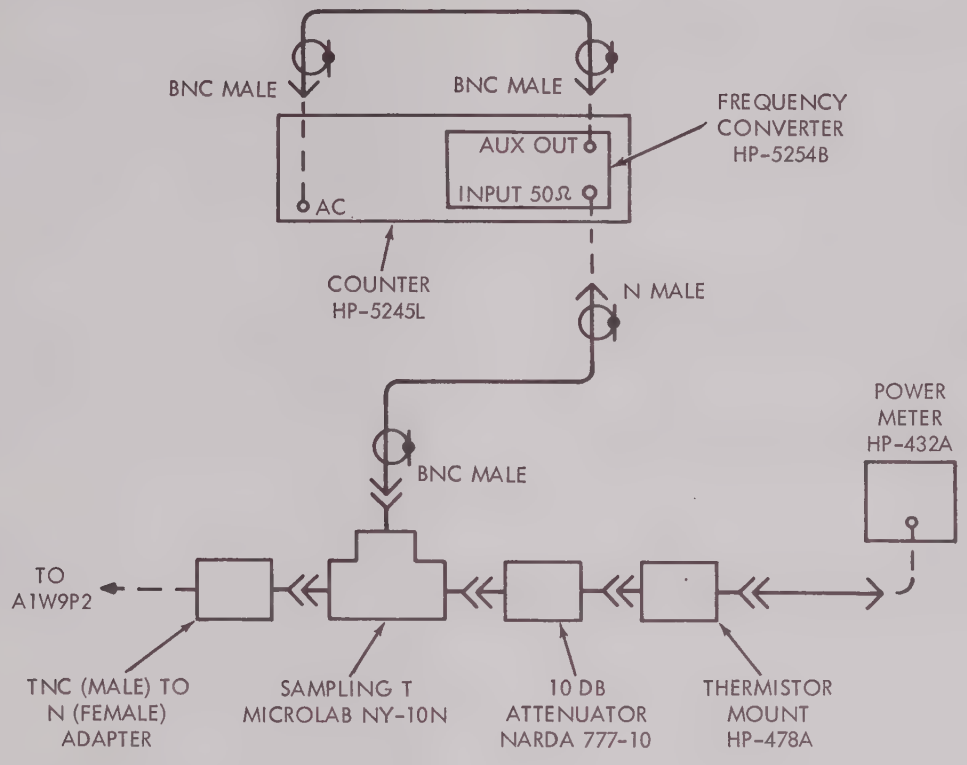


Figure 4-7. 1.92 GHz Second Local Oscillator A1A3 Checkout

meter should indicate between +7 and +9 dBm while the frequency should be 1.920 GHz ±300 kHz. frequency should be 1.920 GHz ± 300 kHz.

d. Disconnect plug A1W9P2 from the adapter and connect it to jack V1.

e. Disconnect plug P1 from jack A1CP5J2. Set the power meter to the +10 dBm range and couple the thermistor mount, using the TNC-to-N adapter, to plug A1A3P1. Note the power indication; it should be between +4.5 and +6 dBm.

f. If the indications of step c and e are obtained the second local oscillator is operating properly; remove the test equipment and connect play A1A3P1 to jack A1CP5J2. If the proper indications are not obtained, troubleshoot the oscillator in accordance with paragraph 4-27.

4-27. Troubleshooting and Alignment

a. Using a Simpson 260 VOM, set to the -50 VDC range, measures the voltage between top filter A1A3F12 and chassis ground; the VOM should indicate -24 volts. If this voltage is not present, check the -24 volt distribution lines.

b. Measure the voltage between bottom filter A1A3FL1 and chassis ground; it should be -12 volts. If this voltage is not present, check the -12 volt (osc) distribution lines.

c. Perform step b of paragraph 4-26 with plug A1A3P1 connected to jack A1CP5J2.

d. Reach through the access hole on top of the oscillator near the power input filters, and rotate feedback capacitor A1A3C1 fully clockwise and

then back off 3 1/2 turns.

e. Reach through the access hold located on the side opposite jack A1A3J1, and adjust the tuning screw until the counter indicates 1.920 GHz ± 1 MHz.

f. Carefully readjust capacitor A1A3C1 to obtain a counter indication of 1.920 GHz ± 300 KHz.

g. Note the power meter indication; it should read between +7 and +9 dBm.

h. Perform steps d and e of paragraph 4-26.

Note

If after performing paragraph 4-27 the 1.92 GHz second local oscillator does not meet the required specifications, remove the assembly from the RF/IF shelf (refer to paragraph 4-66) and return the assembly to the factory. DO NOT ATTEMPT ANY REPAIR PROCEDURES ON THIS ASSEMBLY.

4-28. FREQUENCY DOUBLER A1A4.

Note

Before performing this procedure, note that 3.84 GHz preselector A1FL5 is operating properly.

a. Set an HP-8690B/8699B sweep generator for a CW output of 65 milliwatts at 1.92 GHz.

b. Disconnect plug A1W9P2 from jack A1A5J1 and disconnect plug A1W10P1 from jack A1FL5J2.

c. Interconnect the equipment as illustrated in figure 4-8.

d. Note that the power meter reading is at least 1.7 milliwatts. If it is, the frequency doubler is operating properly; disconnect the test equipment. Couple plug A1W9P2 to jack A1A5J1 and connect plug A1W10P1 to A1FL5J2. If the proper indication is not obtained, install a replacement frequency doubler.

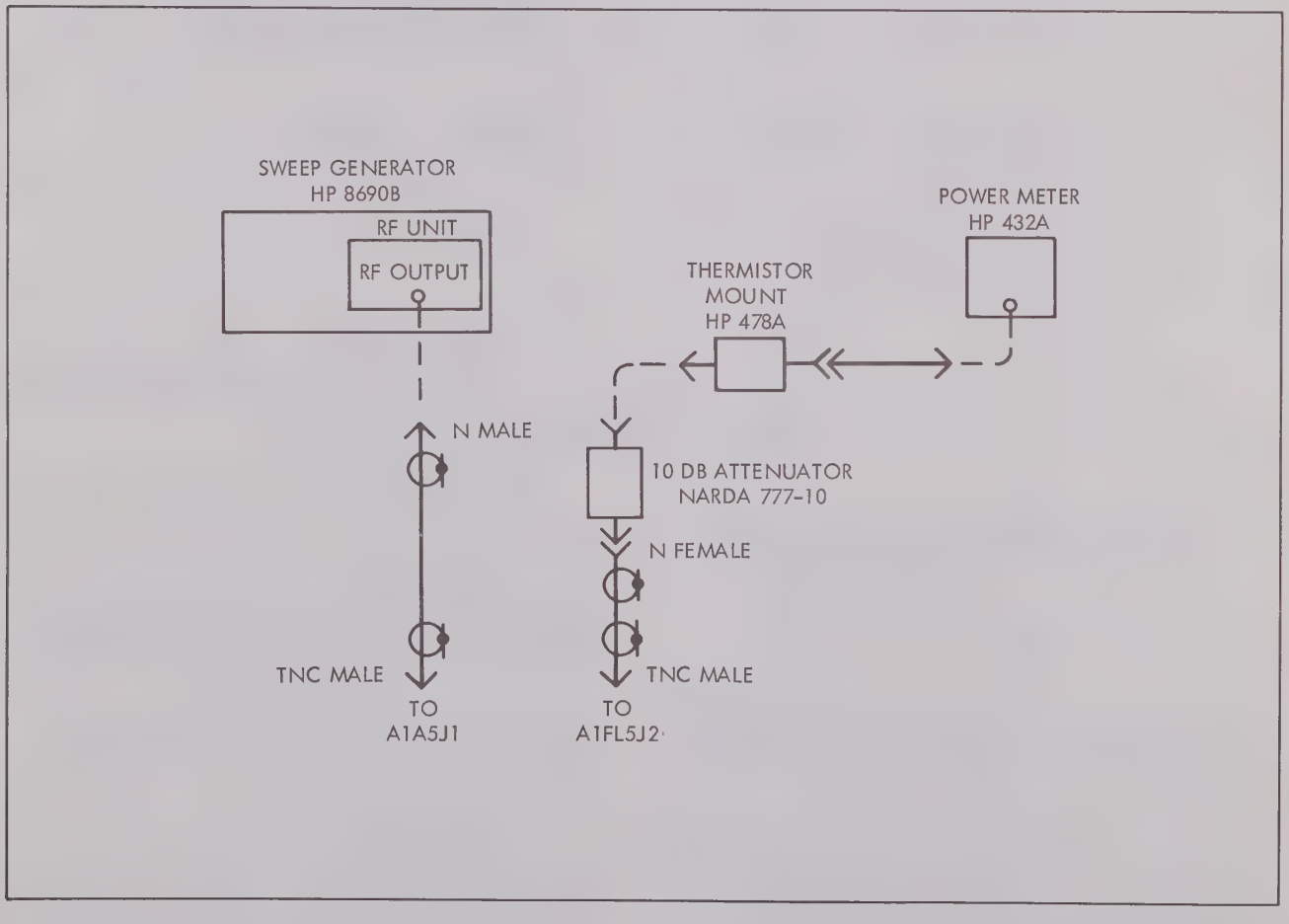


Figure 4-8. Frequency Doubler A1A4 Checkout

4-29. FILTER ASSEMBLIES A1FL1, A1FL2, A1FL3, A1FL6 AND A12FL1. Each of the filters tested require similar procedures for checkout Figure 4-9 provides the test setup. Table 4-5 provides the required test equipment designations not provided on the referenced figure; the desired filter characteristic curve associated with each filter is also referenced in the table. Only 4 GHz notch filter A1FL2 can be aligned if the requirements of the characteristic curves are not met; the alignment procedure is provided in the paragraph. The checkout procedure for all filters is as follows.

a. Connect the equipment as shown in figure 4-9.

b. Using the Weinschel 935 variable attenuator and when necessary, the Filmohm variable attenuator, determine the critical dB reference points indicated on the desired filter characteristic curve referenced in table 4-5.

Note

When the Weinschel 953 variable attenuator is set to 1, 1.8, 8, etc.; insertion loss, the observed trace on the oscilloscope indicates 0, 0.8, 7, etc., dB.

c. Using the MARK 1 and MARK 2 switches, note the critical frequency reference points indicated on the filter characteristic curve.

Note

When checking out notch filter A1FL2 insert an HP-536A frequency meter set to 4.000 GHz in the test set up in location A and adjust the oscilloscope to center the suckout; then insert the filter adjacent to the frequency meter. Tune the frequency meter to determine the precise characteristic curve limitations. If filter alignment is required, tune the frequency meter to exactly 4.000 GHz and alternately adjust each of the three cavity tuning screws until an optimum symmetrical response centered at 4 GHz with the narrowest bandwidth is obtained.

d. Remove the filter from the equipment in accordance with the filter removal paragraph referenced in table 4-5, and insert it at point A. Note the response on the oscilloscope screen; it should be similar to that illustrated in the filter characteristic curve referenced in table 4-5. If the characteristic is observed, the filter is operating properly; install it into the RF-3000. If the proper characteristic is not observed, install a replacement filter.

TABLE 4-5. FILTER ASSEMBLY CHECKOUT

FILTER	SWEEP GENERATOR	MERRIMAC MAGIC TEE	WEINSCHEL 50-OHM TERMINATION	FILTER CHARACTERISTIC FIGURE NO.	FILTER REMOVAL PARAGRAPH NO.
A1FL1	HP-8690B/H01-8694B	CHT-9.0K W/Narda 777T-10 attenuator	535-MT	4-10	4-84
A1FL2	HP-8690B/8693A	CHT-6K	535-MN	4-11 4-12	4-85
A1FL3	HP-8690B/8693A	CHT-6K	535-MN	4-13	4-69
A1FL6	HP-8690B/8699B	CHT-3K	535-MN	4-14	4-67
A12FL1	HP-8690B/8693A	CHT-6K	535-MN	4-15	4-86

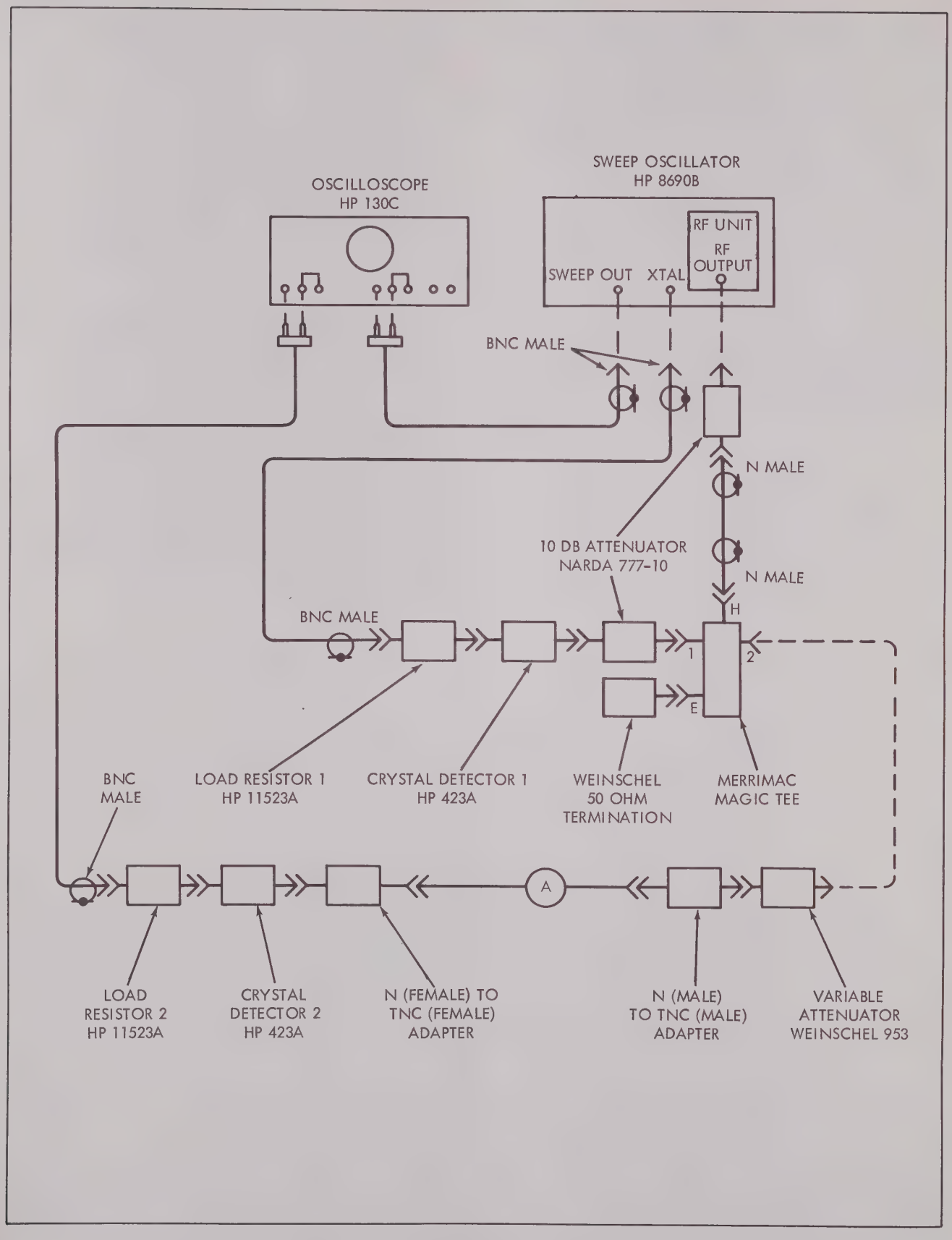


Figure 4-9. Filter Assembly Checkout

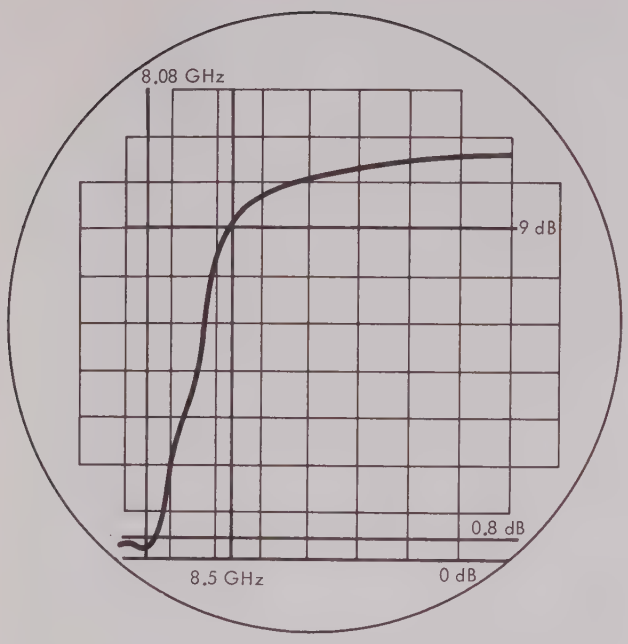


Figure 4-10. Typical Amplitude - Frequency Characteristics of 8 GHz Low-Pass Filter A1FL1

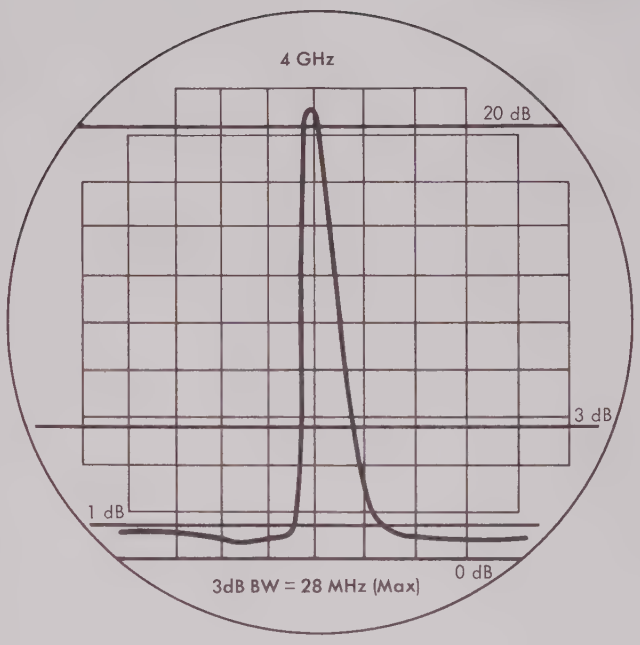


Figure 4-11. Typical Amplitude - Frequency Characteristics of 4 GHz Notch Filter A1FL2 (Notch Region)

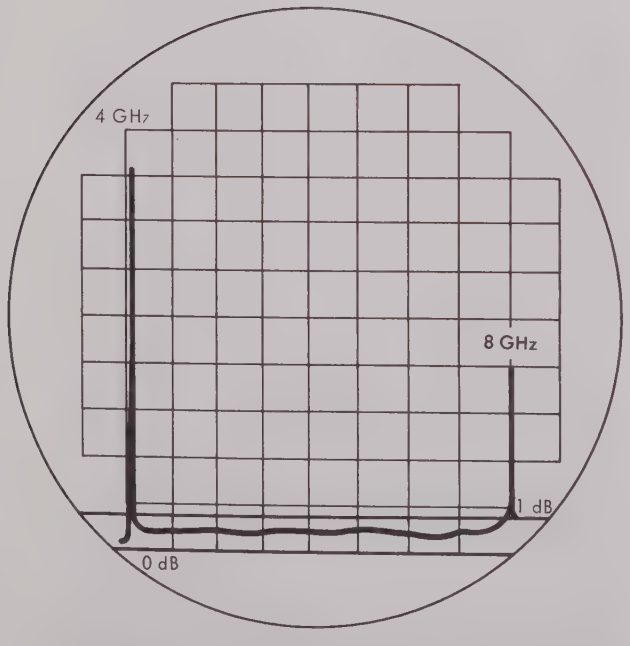


Figure 4-12. Typical Amplitude - Frequency Characteristics of 4 GHz Notch Filter A1FL2

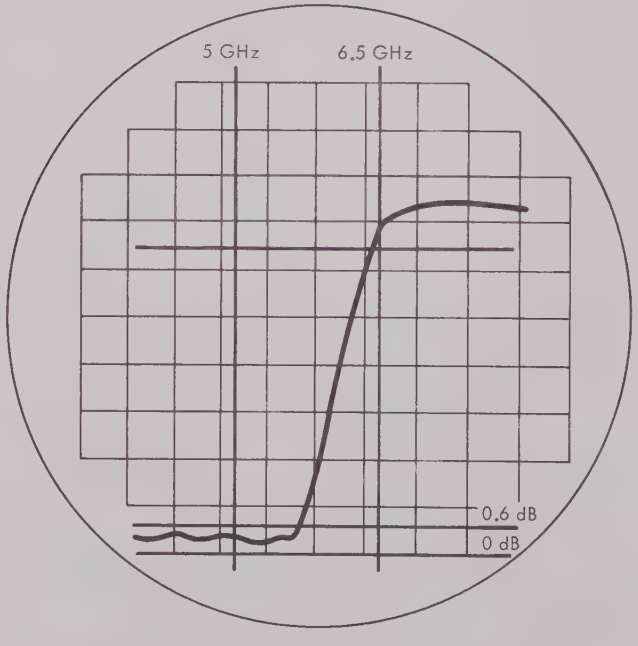


Figure 4-13. Typical Amplitude - Frequency Characteristics of 5 GHz Low-Pass Filter A1FL3

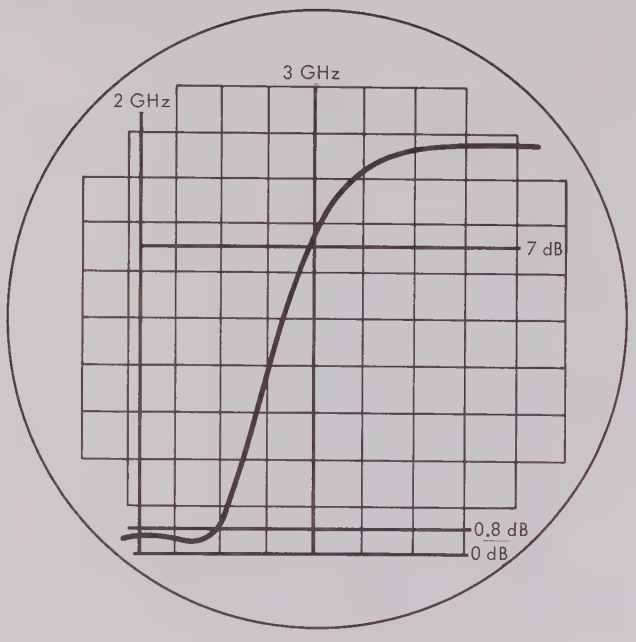


Figure 4-14. Typical Amplitude - Frequency Characteristics of 2 GHz Low-Pass Filter A1FL6

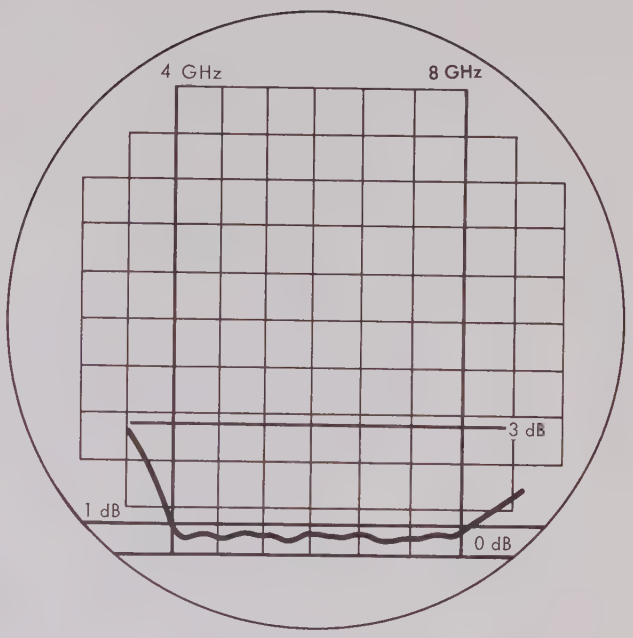


Figure 4-15. Typical Amplitude - Frequency Characteristics of 4 GHz High-Pass Filter A12FL1

4-30. PRESELECTOR ASSEMBLIES A1FL4, A1FL5 AND A1FL7.

4-31. Checkout. Each of the preselectors tested require similar procedures for checkout; figure 4-16 provides the test setup. Table 4-6 provides the required test equipment designations not provided on the referenced figure; the desired preselector characteristic curve associated with each preselector is also referenced in the table. The checkout procedure is as follows:

a. Connect the equipment as shown in figure 4-16.

b. Using the Weinschel 935 variable attenuator determine the critical dB reference points indicated on the desired preselector characteristic curve referenced in table 4-6. (Refer to the note after step b of paragraph 4-29.)

c. Tune the frequency meter to establish the frequency reference points on the oscilloscope as indicated by the preselector characteristic curves referenced in table 4-6.

d. Remove the preselector from the RF-3000 as indicated by the paragraph reference of table 4-6, and insert it into the setup of figure 4-16 in place of the TNC (female-to-female) adapter.

e. Increase the sweep generator output level until the peak of the response is coincident with the 0 dB reference line.

f. Tune the frequency meter to position the "suck out" point at the peak of the response; the frequency meter should indicate the center frequency of the preselector.

g. Tune the frequency meter, in sequence, to position the "suckout" point at the upper and lower 3 dB. points. If the indications obtained are consistent with the characteristic curve referenced in table 4-6, the preselector is functioning properly; replace it into the RF-3000. If the proper indications are not obtained, perform the alignment procedures of paragraph 4-32.

4-32. Alignment.

a. Tune the frequency meter to the exact center frequency of the preselector.

b. Loosen the locknut that secures the setting of each of the cavity tuning screws.

c. Alternately adjust each of the cavity tuning screws until an optimum symmetrical response, centered at the preselector center frequency is attained; carefully tighten the locknuts to secure the setting of each tuning screw. Repeat paragraph 4-31.

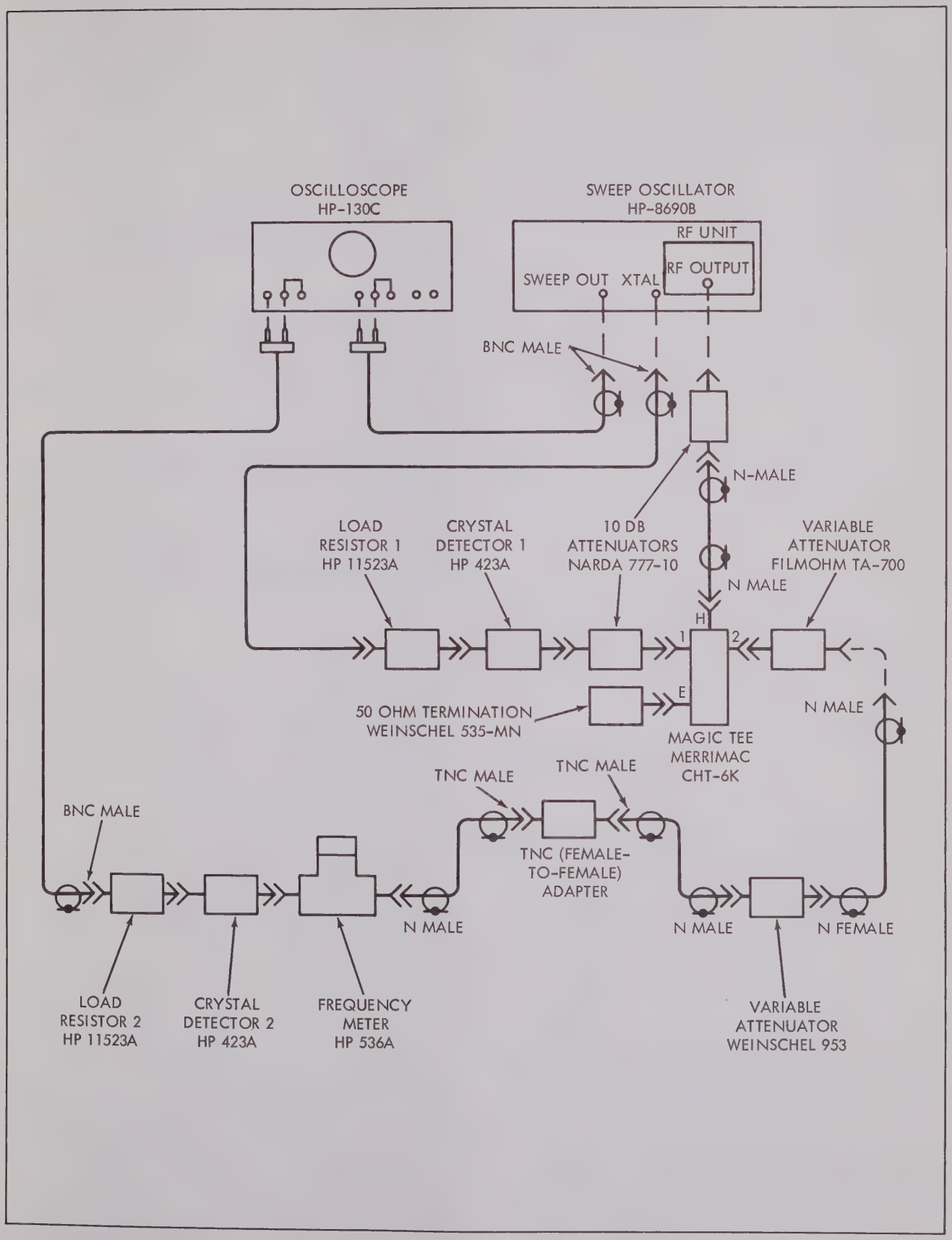


Figure 4-16. Preselector Assembly Checkout

TABLE 4-6. PRESELECTOR ASSEMBLY CHECKOUT

Preselector	Sweep Generator	Merrimac Magic Tee	Preselector Characteristic Figure	Preselector Removal Paragraph
A1FL4	HP-8690B/8693A	CHT-3K	4-17	4-68
A1FL5	HP-8690B/8699B	CHT-6K	4-18	4-72
A1FL7	HP-8690B/8699B	CHT-3K	4-19	4-70

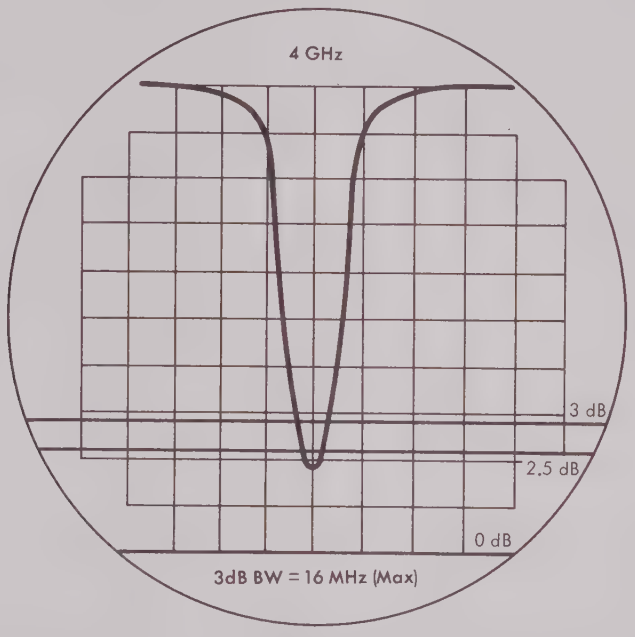


Figure 4-17. Typical Amplitude - Frequency Characteristics of 4 GHz Preselector A1FL4

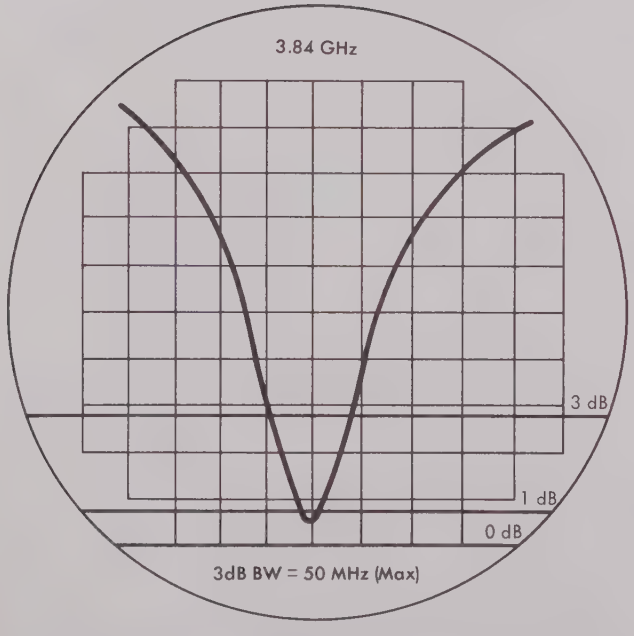


Figure 4-18. Typical Amplitude - Frequency Characteristics of 3.84 GHz Preselector A1FL5

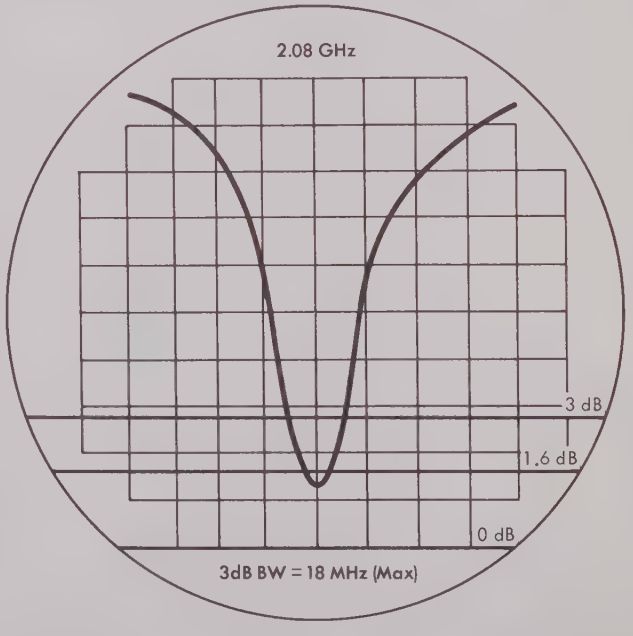


Figure 4-19. Typical Amplitude - Frequency Characteristics pf 2.08 GHz Preselector A1FL7

4-33. BWO V3.

4-34. Output Power Checkout.

a. Remove line power from the RF-3000.

b. Disconnect plug W1P2 from its mating connector on 8 GHz low pass filter A1FL1.

c. Connect a Narda 777-20 20 dB pad and an HP-478A thermistor mount between plug W1P2 (using a TNC female to N female adapter) and an HP-432 power meter.

d. Set the RANGE switch of the RF-3000 to .01-3.5 GHz and depress the O dispersion pushbutton.

e. Apply line power to the RF-3000; depress both the SYSTEM POWER and LO ENABLE pushbuttons, and allow a 10 minute warmup.

f. Slowly rotate the TUNING dial through the entire range; note and record the lowest power indication; it should not be less than 0.3 milliwatts. (This corresponds to a minimum BWO output of 30 mw.)

g. Release the SYSTEM POWER pushbutton; carefully disconnect plug W2P2 from the common (C) jack of A1A5J1 and connect the thermistor mount and power meter to W2P2, using the TNC female to N female adapter.

h. Repeat step f.

i. If the proper indications are not obtained, the BWO is not operating properly. Refer to paragraph 4-81. If the proper indications are obtained, disconnect the adapter from plug W2P2 and release the SYSTEM POWER pushbutton. Correct plug W2P2 to jack A1K5J1.

4-35. Frequency Calibration.

a. Interconnect the Main Frame and RF-3000 and set the controls of the SPA-3000 as follows.

Control	Setting
RANGE switch	.01-3.5 GHz
ATTENUATOR dB switch	0
MHz/DIV pushbutton switch	Depressed
FREQUENCY DISPERSION switch	100
FREQUENCY DISPERSION VARIABLE control	CAL (fully CW)
PHASE LOCK pushbutton switch	Released
RF MARKER pushbutton switch	Released
BANDWIDTH switch	1000 kHz
BANDWIDTH VARIABLE control	CAL (fully CW)
AMPLITUDE SCALE switch	LIN
IF GAIN control	Fully CCW
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	CAL (fully CW)
SWEEP/SYNC switch	INT (black)

b. Connect an HP-608F signal generator to the SIGNAL INPUT .01-12.4 GHz jack; tune it to exactly 400 MHz and adjust the CW output level to 0 dBm.

c. Adjust the TUNING control to 0.4 GHz.

d. Adjust potentiometer A10R9 to position the 400 MHz pip at the graticule f_0 vertical line.

e. Adjust potentiometer A7R39 to position the "zero frequency" pip four divisions (400 MHz) to the left of the graticule f_0 vertical line.

f. Adjust potentiometer A7R26 to position the 800 MHz pip four divisions to the right of the graticule f_0 vertical line.

g. Set the TUNING control to the frequencies listed below and adjust the specified control to position the signal harmonic pip at the right of the screen, four divisions to the right of the f_0 vertical line.

Frequency	Control
0.8 GHz	A7R23
1.2 GHz	A7R20
1.6 GHz	A7R17
2.0 GHz	A7R14
2.4 GHz	A7R11
2.8 GHz	A7R8
3.2 GHz	A7R5
First dot at right of scale	A7R2
Second dot at right of scale	A10R10

h. Repeat steps d through g until the proper indications are obtained without further adjustment.

i. Disconnect the HP-608F and connect an HP-8406A comb generator to the SIGNAL INPUT .01-12.4 GHz jack; press the 100 MHz marker

pushbutton; set the BANDWIDTH switch of the RF-3000 to 100 kHz.

j. Adjust the TUNING control to 0.01; note the "zero frequency" pip at the left of the CRT f_o vertical graticule line.

k. Position the "zero frequency" pip, using the SIGNAL FREQ POSITION f_o control, at, or slightly to the right of the CRT f_o vertical graticule line.

l. Adjust the comb generator output level until the markers appear.

m. Adjust potentiometer A7R73 until a single marker appears to the left of the "zero frequency" pip.

n. Position the pointer associated with the TUNING control, at the second dot to the right of the scale.

o. Adjust potentiometer A7R75 until four markers appear to the right of the CRT f_o vertical graticule line.

p. Disconnect the comb generator and perform the preliminary adjustments of paragraph 2-12.

4-36. RADIAL LINE MIXER A1A4.

a. With the RF-3000 coupled to the Main Frame, set the RANGE switch to .01-3.5 GHz; set the FREQUENCY DISPERSION switch to 300; set the FREQUENCY DISPERSION VARIABLE control to CAL; and depress the kHz/DIV pushbutton.

b. Set the AMPLITUDE SCALE switch to PWR. Set the TUNING control to obtain a pointer indication of 0.4.

c. Connect an HP-608F signal generator to the SIGNAL INPUT .01-12.4 GHz jack, and provide a 400 MHz, CW, minimum level output.

d. With the BANDWIDTH switch set to 100 kHz, the BANDWIDTH VARIABLE control set fully clockwise, the SWEEP switch set to 3 MS/DIV and the SWEEP VARIABLE control set to CAL, set the SWEEP/SYNC switch to INT (black).

e. Set the ATTENUATOR dB switch to 0 and check that both the PHASE LOCK and RF MARKER pushbuttons are released.

f. Adjust the IF GAIN control for a noise display 1 division high.

g. Increase the signal generator output to obtain a signal pip five divisions high.

h. Adjust the cavity tuning screw of radial line mixer A1A4 to peak the response of the 400 MHz pip.

i. Adjust the signal generator output level to obtain a pip peak coincident with the PWR scale .2 horizontal line; the signal generator output level should be -89 dBm ± 2 dB.

4-37. FIRST MIXER CRYSTAL CURRENT.

a. Set the RANGE switch to the band employing harmonic mixing which does not meet the specification requirements for flatness or sensitivity.

b. Connect the probe of an HP-428B clip-on milliammeter to pin W (wiper arm) of S10B (RANGE switch set to 4.5-10 GHz or 9-12.4 GHz) or S10C (bands 5 through 9).

c. Adjust the control as indicated below until the proper flatness and sensitivity requirements provided in paragraph 4.2 step 10 are met.

RANGE Switch Setting	Nominal Xtal Current	Control
4.5-10 GHz	0.5 ma	A10R11
9-12.4 GHz	0.5 ma	A10R12
12.4-15.5 GHz	0.45 ma	A10R13
15-21 GHz	2 ma	A10R14
20-26.5 GHz	0.7 ma	A10R15
26.5-31 GHz	3 ma	A10R16
30-40 GHz	4 ma	A10R17

4-38. SECOND MIXER/160 MHZ PREAMPLIFIER A1A1 AND 160 MHZ BAND-PASS FILTER/AMPLIFIER A1A2.

4-39. Checkout.

a. Set the RF-3000 RANGE switch to .01-3.5 GHz and disconnect plug A1W7P2 from jack A1CP3J1. Disconnect plug A1W10P2 from jack A1CP3J2

b. Connect the probe of an HP-428B clip-on milliammeter to the wire shorting inductor A1A1FL1 to ground.

c. Tune an HP-612 signal generator for a cw output of 770 MHz. Couple the signal generator to jack A1CP3J2 and adjust the output level to obtain a clip-on milliammeter indication of 3.2 ma.

d. Couple the horizontal input of an HP-130C oscilloscope to a Jerrold 900B sweep generator (SCOPE HORIZ jack); position the oscilloscope trace on the lowest graticule horizontal line.

e. Connect the RF OUTPUT jack of the sweep generator to the input of a Jerrold D-50B detector; connect a 50-ohm termination to the remaining detector input jack.

f. Set the FREQUENCY MEGACYCLES control of the sweep generator for a dial indication of 160 (wide sweep width) with 10 mc markers.

g. Adjust the sweep generator to provide a 350 mv signal, measured on the oscilloscope, and then fine tune the frequency to position the 160 MHz marker at the center of the screen.

h. Rotate the sweep generator SWEEP WIDTH control until both the 150 and 170 MHz markers appear on the screen and pull out the sweep generator 1 MC MARKER switch.

i. Connect the test setup illustrated in figure 4-20.

j. Set attenuator 1 for 0 dB insertion and attenuator 2 for 6 dB insertion.

k. Increase the sweep generator output to obtain the display of figure 4-21 (50mv/cm, with a 1 dB bandwidth of 4 MHz centered at 160 MHz).

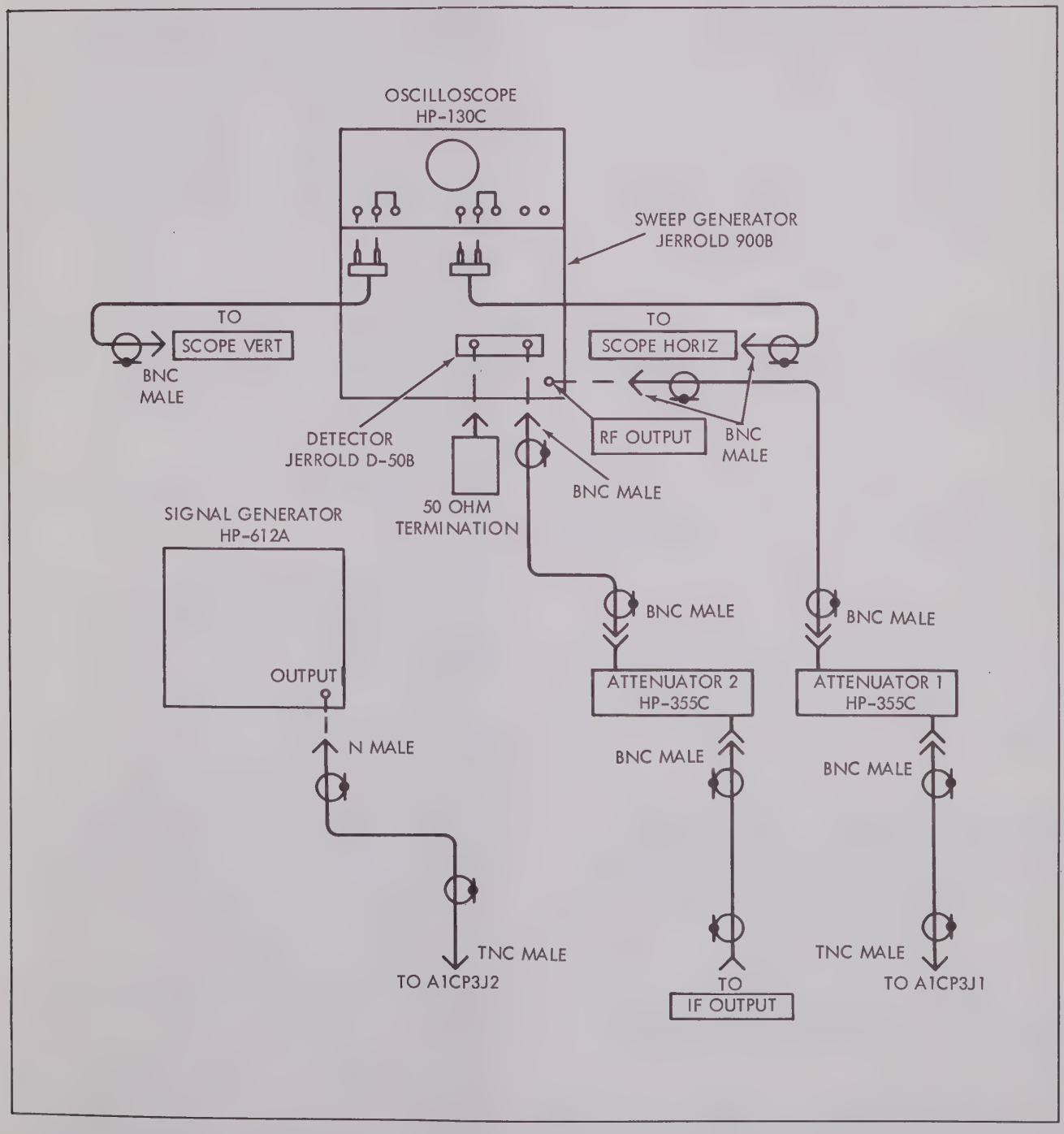


Figure 4-20. Second Mixer/160 MHz Preamplifier A1A1 and 160 MHz Band-Pass Filter/Amplifier A1A2 Checkout.

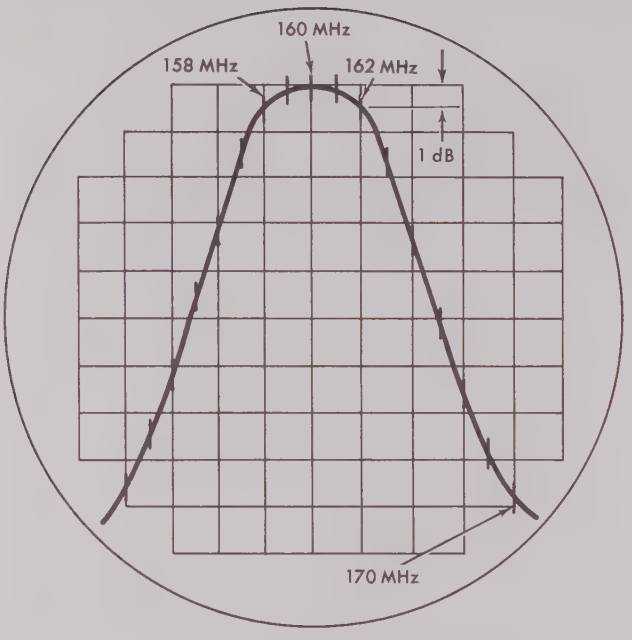


Figure 4-21. Typical Amplitude-Frequency Characteristics of Second Mixer/160 MHz Preamplifier A1A1 and 160 MHz Band-Pass Filter/Amplifier A1A2

l. Carefully rotate the sweep generator SWEEP WIDTH control clockwise until the 170 MHz marker is within the graticule grid. Note the response at 170 MHz; it should be no greater than 35 mv (0.7 div).

m. Adjust the sweep generator output level to position the peak of the response coincident with the top graticule horizontal line. Set attenuator 1 for 6 dB insertion and attenuator 2 for 0 dB insertion. Note the position of the response peak; it should be coincidental with, or above, the top horizontal graticule line.

n. If all of the proper indications are obtained, disconnect the test equipment and connect cables A1W7 and A1W10 to coaxial coupler A1CP3. If the proper indications are not obtained, disconnect the test equipment and refer to paragraph 4-40, trouble shooting and alignment.

4-40. Troubleshooting and Alignment.

a. With the RF-3000 energized and the RANGE switch set to 3-6 GHz, set a Simpson VOM to the -50 VDC range. Connect the common lead of the VOM to chassis ground.

b. Connect the + lead of the VOM to filter A1A1FL3 (orange/white lead soldered to it). Note the VOM indication; it should be -26 volts. If the voltage is not present check the -26 volt distribution lines.

c. Connect the + lead of the VOM to filter A1A1FL4 (two blue leads soldered to it). Note the VOM indication; it should be -12 volts. If the voltage is not present, check the -12 volt power distribution.

d. Repeat step b with the VOM + lead connected to filter A1A1FL1. If the operating voltages are applied to Second Mixer/160 MHz Preamplifier A1A1 and 160 MHz Filter/Amplifier A1A2, remove the VOM and proceed.

e. Release the SYSTEM POWER pushbutton. Disconnect all cables and Ts from assembly A1A1. Remove cable A1W8. Loosen and remove the four screws that secure both assemblies A1A1 and A1A2 to the RF/IF shelf. Remove the cover plate that separates assemblies A1A1 from A1A2.

f. Depress the SYSTEM POWER switch and measure the voltages at A1A1Q1 and A1A2Q1 (see table 4-8); perform the required repairs or replacements.

g. Perform steps d, e, and f of paragraph 4-39.

h. Connect the equipment as shown in figure 4-20 without the HP-612A signal generator and set the RANGE switch to .01-3.5 GHz.

i. Set attenuator 1 for 0 dB insertion and attenuator 2 for 7 dB insertion.

j. Increase the sweep generator output level to obtain a display whose peak is 300 mv (6 divisions) high.

k. Alternately adjust capacitors A1A2C12, A1A2C8, A1A2C5, and A1A2C2 to peak the response at 160 MHz. Repeat these adjustments to obtain an optimum response centered at 160 MHz. (Readjust the sweep generator output level to maintain the response peak 300 mv high.)

l. Detune capacitor A1A2C5 towards 150 MHz to obtain a response similar to that shown in figure 4-22a.

m. Perform step i and alternately tune capacitors A1A2C12, A1A2C8, and A1A2C2 to peak the response at 160 MHz. Repeat these adjustments to obtain an optimum response centered at 160 MHz. The display should be similar to that of figure 4-22b.

n. Tune capacitor A1A2C5 towards 160 MHz to obtain the response of figure 4-22c.

o. Increase the sweep generator output level to position the response peak coincident with the top graticule horizontal line, (500 mv).

p. Determine the 1 dB bandwidth; it should be approximately 2 MHz.

q. Set attenuator 1 for 7 dB insertion and attenuator 2 for 0 dB insertion. Note the peak of the response; it should be coincident with, or above,

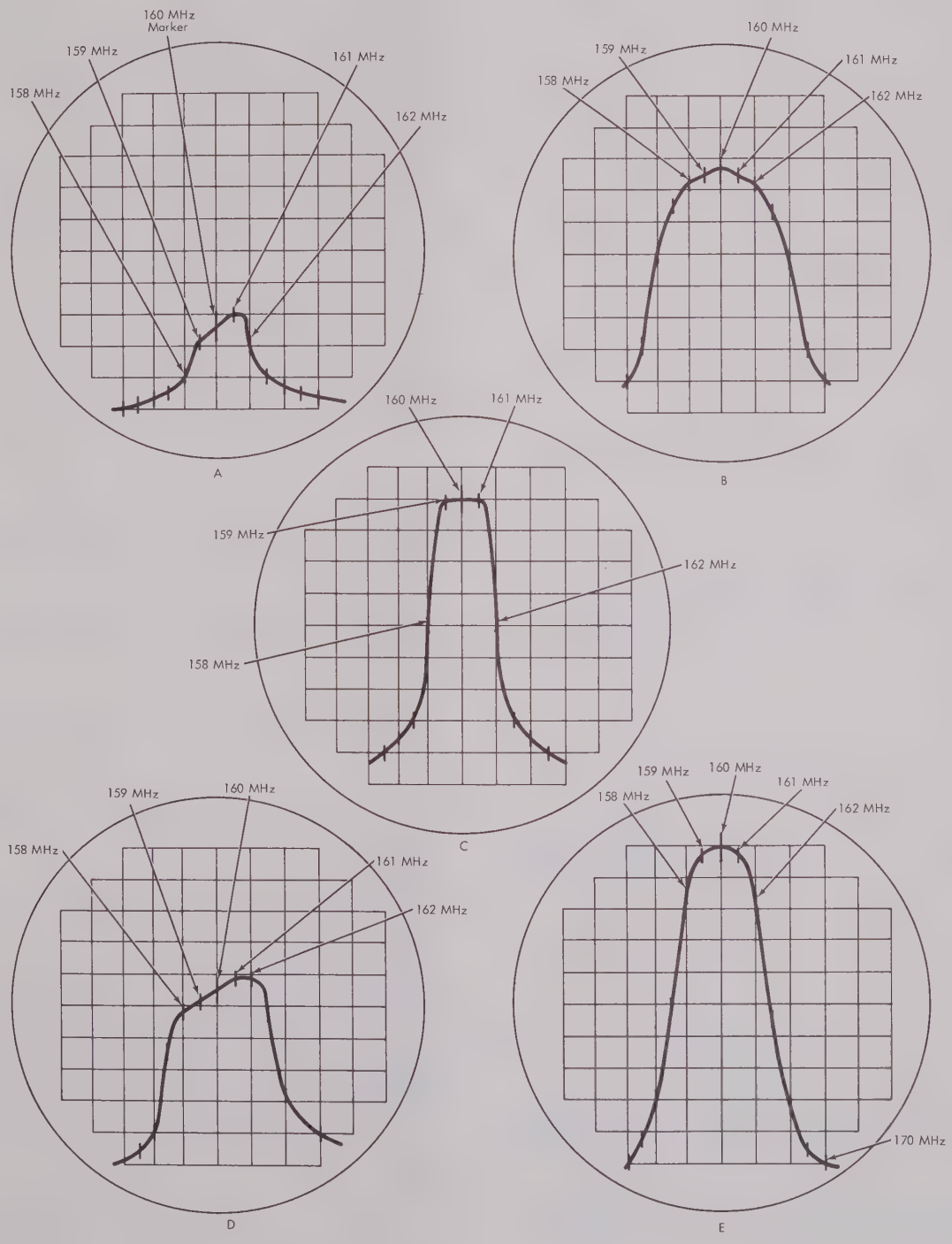


Figure 4-22. Typical Responses During Alignment of A1A1 and A1A2.

the top graticule horizontal line. Disconnect the cable from jack A1A2J1.

r. Disconnect plugs A1W7P2 and A1W10P2 from coaxial coupler A1CP3. Connect coupler A1CP3 to jack A1A1J1.

s. Perform step c of paragraph 4-39.

t. Replace the cable from attenuator 1 to jack A1A2J1 with one having a TNC female connector instead of a TNC male connector. Couple this cable between the attenuator and jack A1CP3J1. Connect cable A1W8 between jack A1A1J3 and jack A1A2J1.

u. Set attenuator 1 for 0 dB insertion and attenuator 2 for 6 dB insertion.

v. Adjust the sweep generator output lead to position the response peak at 300 mv (6th horizontal graticule line).

w. Tune capacitor A1A1C4 to peak the response at 160 MHz. Then detune capacitor A1A1C4 towards 150 MHz until the gain at 160 MHz drops approximately 1 dB (see figure 4-22 d).

x. Tune capacitor A1A2C8 to peak the response at 160 MHz. Increase the sweep generator output level to position the response peak with the top graticule horizontal line (500 mv). (See figure 4-22e.) Note the 1 dB bandwidth; it should be 4 MHz centered about 160 MHz. Note the response at 170 MHz; it should be no greater than 35 mv (0.7 div).

y. Set attenuator 1 for 7 dB insertion and attenuator 2 for 0 dB insertion. Note the position of the response peak; it should be coincident with or above the top graticule line (500 mv).

z. Disconnect the test equipment, de-energize the RF-3000 and install assemblies A1A1 and A1A2 back into the system. Make sure all cables and Ts are properly connected.

4-41. RF MARKER.

a. With the RF-3000 connected to the main frame and the SPA-3000 energized, release both the LO ENABLE and RF MARKER pushbuttons.

b. Depress the MHz/DIV pushbutton and rotate the IF GAIN control fully counterclockwise. Note the position of the display base line.

c. Depress the RF MARKER pushbutton and adjust potentiometer A8R5 to position the base line with the top graticule horizontal line.

d. Release the RF MARKER pushbutton.

4-42. 29 MHz PULLED OSCILLATOR A11.

4-43. Checkout.

a. Disconnect cable W4P2 from jack A12A1J1.

b. Set an HP-432A power meter to the +10 dBm range and interconnect the equipment as illustrated in figure 4-23.

c. Energize the RF-3000, and after a few minutes warmup, note the power meter indication. Slowly rotate the PHASE LOCK ADJUST control throughout its range and observe the variation in output level; it should be less than 2 mw.

d. Disconnect the thermistor mount and couple the 10 dB pad to an HP-5244L counter. Slowly rotate the PHASE LOCK ADJUST control throughout its range. The difference between the highest and lowest frequencies should not be less than 120 kHz.

e. If the indications of steps c and d are obtained, the 29 MHz pulled oscillator is operating properly; disconnect the test equipment; connect cable W4P2 to jack A12A1J1 and proceed to paragraph 4-45. If the proper indications are not obtained, perform the steps of paragraph 4-44.

4-44. Troubleshooting and Alignment.

a. With the RF-3000 de-energized, withdraw 29 MHz pulled oscillator A11 as directed in paragraph 4-76.

b. Energize the RF-3000 and measure the voltage between filter A11FL1 and assembly ground; it should be -12 volts.

c. Remove the four screws that secure the cover plate to A11. Remove the single screw that secures the top cover plate to capacitor A11C1.

d. Measure the voltages at transistor A11Q1 (see table 4-19); effect the necessary repairs or replacements.

e. With the test equipment connected as shown in figure 4-23, adjust capacitor A11C1 for minimum capacitance (plates out).

f. Tune capacitor A11C6 for a maximum power meter indication. If no power meter indication is obtained, set capacitor A11C6 to mid-range and adjust capacitor A11C2 until power is indicated and then adjust capacitor A11C6 for maximum power indication.

g. De-energize and then re-energize the RF-3000. The power meter should still indicate the level of step f.

h. Replace the thermistor mount and power meter with an HP-5244L counter.

i. Tune capacitor A11C1 for maximum capacitance (plates fully enmeshed).

j. Adjust capacitor A11C2 to obtain a counter indication as near to 29.030 MHz as possible.

k. Tune capacitor A11C1 for minimum capacitance.

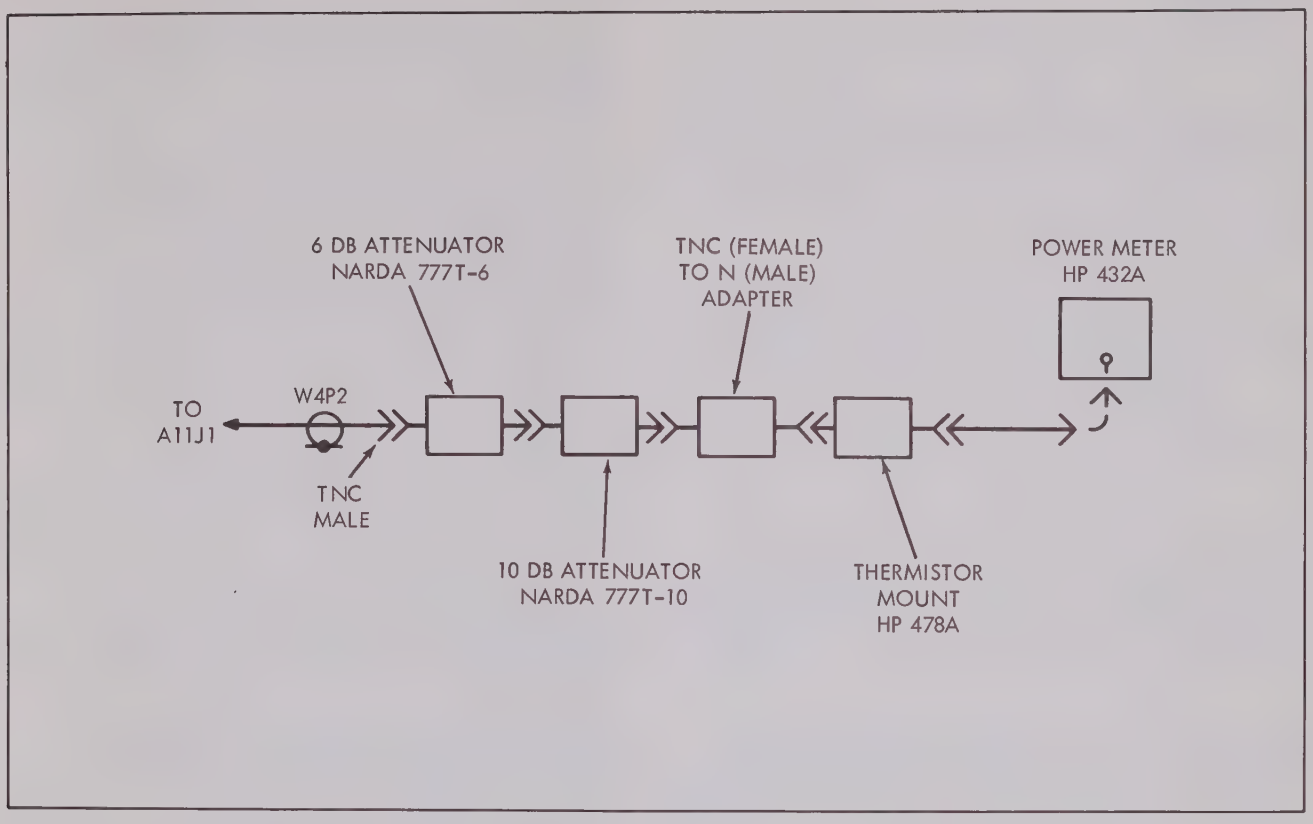


Figure 4-23. 29 MHz Pulled Oscillator A11 Checkout

l. Note the counter indication; it should be between 29.150 and 29.165 MHz.

m. Repeat step i and note the counter indication; it should be between 29.026 and 29.035 MHz. If it is not within these limits, repeat steps j through m.

n. Replace the counter with the thermistor mount and power meter. Rotate capacitor A11C1 throughout its range and note the power meter indication; it should not vary more than 2 milliwatts.

o. Disconnect the test equipment, secure the cover plates to the assembly and replace pulled oscillator assembly A11 into the RF-3000.

4-45. COMB GENERATOR A12A1.

4-46. Checkout.

Note

This procedure assumes that both 29 MHz pulled oscillator A11 and 4 GHz high-pass filter A12FL1 have been checked per paragraphs 4-42 and 4-29, respectively, and are operating properly.

a. With the RF-3000 connected to the main Frame and the SYSTEM POWER pushbutton released, disconnect plug A12W2P1 from the output of filter A12FL1.

b. Set the controls of the SPA-3000 for a log display of 1 GHz dispersion with a center frequency of 4.5 GHz (band 2).

c. Couple the output of filter A12FL1 to the SIGNAL INPUT .01-12.4 GHz jack.

d. Energize the SPA-3000 and depress the LO ENABLE pushbutton switch. After the delay period has elapsed, a comb of signals (spaced approximately 29 MHz apart) should appear.

e. Tune an HP-618C signal generator to 4.2 GHz and adjust it for a cw output of approximately -35 dBm.

f. Note the amplitude of the frequency comb component corresponding to 4.2 GHz.

g. Connect the signal generator output to the SIGNAL INPUT .01-12.4 GHz jack instead of the output of filter A12FL1. Note the amplitude of the response; it should be comparable to that of step f.

h. Disconnect the signal generator and repeat step c.

i. Rotate the TUNING control clockwise, while observing the display, until a pointer indication of 5.5 GHz is obtained. The comb should move across the screen from right to left, decreasing slightly in amplitude. There should be no "holes" (i.e., missing frequency components).

j. Set the RANGE switch to 4.5-10 GHz and adjust the TUNING control to obtain a pointer indication of 5 GHz. Repeat step i until a pointer indication of 8 GHz rather than 5.5 GHz is attained.

k. Note the amplitude of the frequency comb component corresponding to 8.8 GHz.

l. Tune an HP-620B signal generator to 8.8 GHz and adjust for a cw output of approximately -45 dBm.

m. Couple the signal generator output to the SIGNAL INPUT .01-12.4 GHz jack. Note the amplitude of the response; it should be comparable to that noted in step k.

n. Disconnect the signal generator. If the indications of steps d, g, i, j and m are obtained, the comb generator is operating properly; couple plug A12W2P1 to jack A12FL1J2. If these indications are not obtained, proceed to paragraph 4-47.

4-47. Troubleshooting and Alignment.

a. Connect the "+" lead of a Simpson 260 VOM (set to the -50 VDC range) to filter A12A1FL1; connect the "common" lead to chassis ground. Note the VOM indication; it should be -12 volt. If this indication is not obtained, check the -12 volt power distribution line.

b. Remove the RF-3000 from line power and remove the phase lock bracket (refer to paragraph 4-77).

c. Loosen and remove the two flat head screws that secure the comb generator to the phase lock bracket.

d. Loosen and remove the four screws that secure the cover plates to comb generator A12A1. Remove the cover plates.

e. Connect plug A12P1 to Jack J13 and energize the RF-3000. Measure the voltages at transistor A12A1Q1 (see table 4-20). Effect the necessary repairs or replacements.

f. Remove the two screws and associated washers that secure the diode clamp block to the comb generator housing. Carefully remove the diode clamp block.

g. Remove the rubberized pressure pad and grounding ring. Using a tweezer or a long-nosed pliers, carefully withdraw diode A12A1CR1 from its seat.

h. Using a Simpson 260 VOM (set to the Rx100 range), measure the forward and back resistance of the diode; these should be typically 1.2 kilohms and infinity, respectively.

i. If the indications of step h are obtained, carefully replace the diode into its seat. If they are not obtained, install a replacement diode. Place the grounding ring and rubberized pressure pad (removed in step g), in that order, over the diode and then replace the clamp block.

j. Couple jack A12A1J2 to the input of filter A12FL1.

k. Connect plug A12P1 to jack J13.

l. Perform steps a through d of paragraph 4-45.

m. Adjust capacitor A12A1C3 to obtain markers maximum amplitude.

n. De-energize the RF-3000, disconnect the test equipment and connect plug A12W2P1 to jack A12FL1J2.

o. Replace the top and bottom cover plates to comb generator A12A1 and secure A12A1 to the phase lock bracket. Install the phase lock bracket into the RF-3000.

4-48. 21 MHz AMPLIFIER A12A2.

4-49. Checkout.

a. Set the controls of a Jerrold 900B sweep generator to provide a dial indication of 20 (wide sweep width) with 10 mc markers.

b. Couple the horizontal input of an HP-130C oscilloscope to the sweep generator (SCOPE HORIZ jack); position the oscilloscope trace on the lowest graticule horizontal line.

c. Connect the RF OUTPUT jack of the sweep generator to the input of a Jerrold D-50B detector; connect a 50-ohm termination to the remaining detector input jack.

d. Adjust the sweep generator output level to obtain a trace 6 divisions high (at .2 V/CM), and adjust the FREQUENCY MEGACYCLES control to position the 20 MHz marker at the center of the screen.

e. Pull out the 1 MHz MARKER switch and adjust the FREQUENCY MEGACYCLES control to position the 21 MHz marker at the center of the screen.

f. Adjust the SWEEP WIDTH control for a sweep of 20 MHz.

g. Disconnect plug A12W3P2 from the input to isolator A12AT3.

h. Disconnect plug W6P1 from the output of 21 MHz amplifier A12A2.

i. Adjust the sweep generator for minimum output level.

j. Remove the single screw that secures isolator A12AT3 to its mounting bracket.

k. Unscrew A12XCR1 from coupler A12A2CP1.

l. Withdraw diode A12CR1 from its seat.

m. Connect the equipment as illustrated in figure 4-20 except that the attenuator outputs go to coaxial coupler A12A2CP1 (attenuator 1) and jack A12A2J1 (attenuator 2). Set attenuator 1 for 0 dB insertion and attenuator 2 for 10 dB insertion.

n. Increase the sweep generator output level to obtain a 2 volt response peak (the top graticule horizontal line). Note the display; it should have a 3 dB bandwidth (centered at 21 MHz) of approximately 11 MHz.

o. Set attenuator 1 for 10 dB insertion and attenuator 2 for 0 dB insertion. Note the peak of the response; it should be coincident with or above the top graticule horizontal line (2 volts).

p. If the indications of steps n and o are obtained, the 21 MHz amplifier is operating properly. Disconnect the test equipment, replace diode A12CR1 into coaxial coupler A12A2CP1 and connect A12XCR1 (and coaxial coupler A12AT3) to 21 MHz Amplifier A12A2. Secure isolator A12AT3 to its mounting bracket using the hardware removed in step j. If these indications are not obtained, proceed to paragraph 4-50.

4-50. Troubleshooting and Alignment.

a. Using a Simpson 260 VOM (set to the +50 VDC range), measure the voltage between filter A12A2FL1 and chassis ground; it should be +12 volts. If this voltage is obtained; proceed to step b.

b. Remove phase lock bracket A12 from the RF-3000 (refer to paragraph 4-77).

c. Remove the four screws that secure 21 MHz amplifier A12A2 to the bracket. Remove the cover plate.

d. Energize the RF-3000 and measure the voltages at transistor A12A2Q1 (refer to table 4-21). Perform the required repairs or replacements.

e. Perform steps a through m of paragraph 4-49.

f. Increase the sweep generator output level to obtain a 1.2 volt display (approximately six divisions high).

g. Adjust indicator A12A2L1 to obtain a symmetrical response centered at 21 MHz.

h. Repeat steps n and o of paragraph 4-49.

i. De-energize the RF-3000, disconnect the test equipment and replace diode A12CR1 into coaxial coupler A12A2CP1. Connect A12XCR1 (and isolator A12AT3) to 21 MHz amplifier A12A2 and then secure isolator A12AT3 to its mounting bracket. Replace phase lock bracket A12 into the RF-3000.

4-51. 21 MHZ REFERENCE OSCILLATOR A2A2.

4-52. Checkout.

a. With the RF-3000 unenergized and placed upside-down, remove the six screws that secure the cover plate to phase lock casting A2. Remove the cover plate; the components and printed circuit boards will be visible and accessible. (See figure 4-24.)

b. Disconnect plug A2W2P1 from jack A2A2J1.

c. Connect the ground lead of a Tektronix 545A oscilloscope, with a type CA plug-in and a 10:1 probe, to casting ground; connect the probe tip to the center conductor of jack A2A2J1. Couple the probe (through a 6 dB BNC pad) to the oscilloscope vertical input jack.

d. Energize the RF-3000 and depress the PHASE LOCK pushbutton switch. Note the oscilloscope response (.2V/cm amplitude and .1 μs sweep); a symmetrical sinewave having a peak-to-peak amplitude of at least two divisions (8 volts) should be observed.

e. Disconnect the probe/attenuator from the oscilloscope and connect it to the AC SIGNAL INPUT jack of an HP-5244L counter. Note the counter indication; it should be 21 MHz ± 1200 Hz.

f. If the indications of steps d and e are obtained, the 21 MHz reference oscillator is functioning properly; disconnect the test equipment and connect plug A2W2P1 to jack A2A2J1. If these indications are not obtained, proceed to paragraph 4-53.

4-53. Troubleshooting and Alignment.

a. Using a Simpson 260 VOM, measure the voltage between pins 1 and 2 of plug A2P2; it should be +12 volts. If this indication is not obtained, check the +12 volt distribution lines.

b. De-energize the RF-3000, remove the four screws that secure the assembly to the casting and carefully withdraw 21 MHz reference oscillator A2A2.

c. Energize the RF-3000 and, with the PHASE LOCK pushbutton switch still depressed, measure the voltages at transistors A2A2Q1 and A2A2Q2 (see table 4-10); perform the necessary repairs and/or replacements.

d. Perform steps c and d of paragraph 4-52.

e. With the RF-3000 energized, adjust capacitor A2A2C5 for a clean sinewave having a maximum peak-to-peak amplitude.

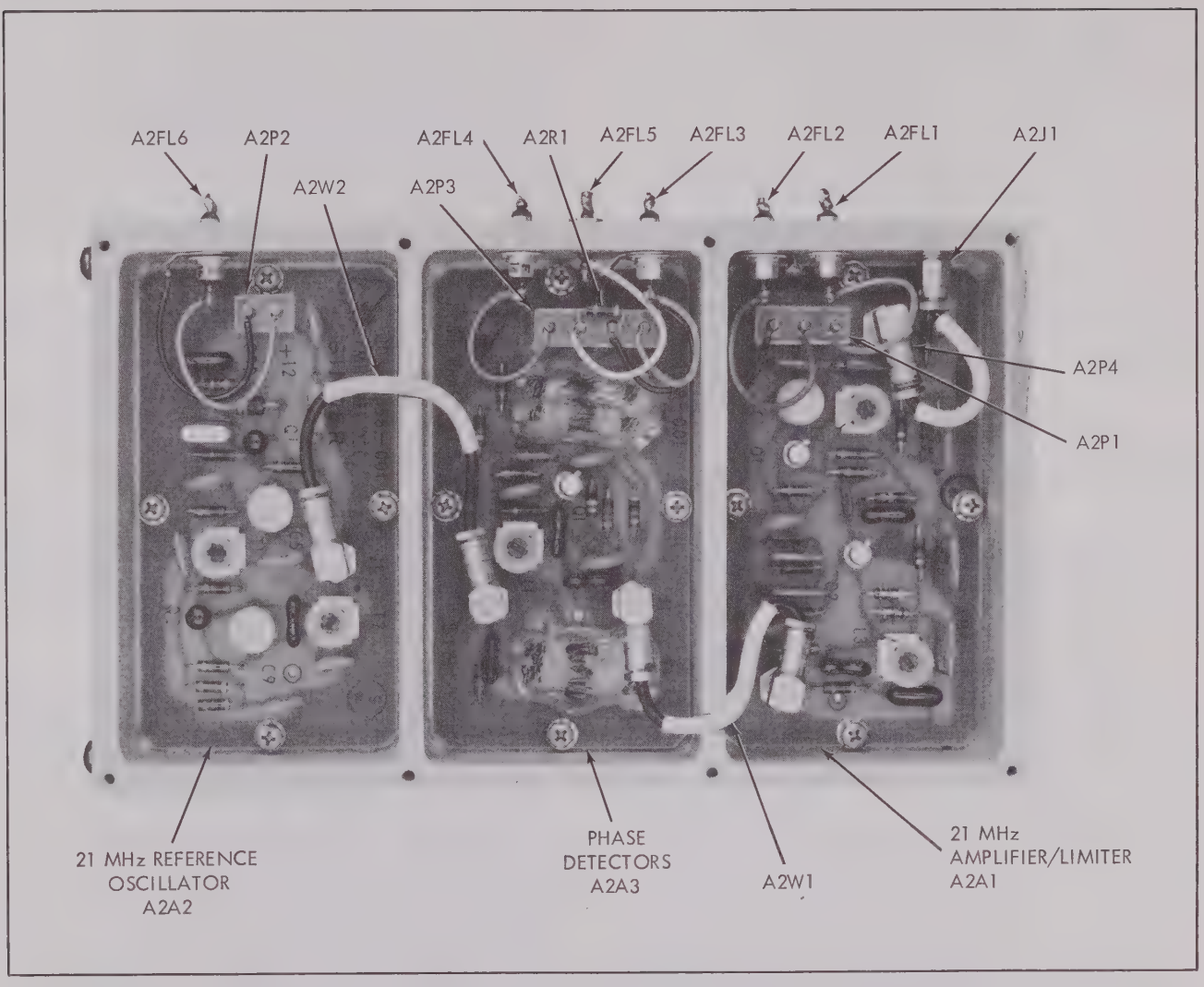


Figure 4-24. Phase Lock Casting A2, Component Locations

f. Tune transformer A2A2T1 for a symmetrical sinewave.

g. Adjust capacitor A2A2C9 for a symmetrical sinewave having a maximum peak-to-peak amplitude.

h. Tune transformer A2A2T2 for maximum peak-to-peak amplitude.

i. Repeat steps e through h until a symmetrical sinewave having a peak-to-peak amplitude of two divisions at a setting of .2 v/cm (8 volts), minimum, is obtained.

j. Repeat step e of paragraph 4-52.

k. De-energize the RF-3000, disconnect the test equipment and replace 21 MHz reference oscillator A2A2 into A2. Connect plug A2W2P1 to jack A2A2J1 and replace the cover plate to casting A2.

4-54. 21 MHZ AMPLIFIER/LIMITER A2A1.

4-55. Checkout.

a. Perform step a of paragraph 4-52.

b. Disconnect plug A2P4 from jack A2A1J1.

c. Disconnect plug A2W1P1 from jack A2A1J2.

d. Tune an HP-608F signal generator to 21 MHz and adjust for a minimum cw output level.

e. Couple an HP-432A power meter (through an HP-478A thermistor mount) to jack A2A1J2.

f. Energize the RF-3000, depress the PHASE LOCK pushbutton switch and increase the signal generator output level to -30 dBm. Note the power meter indication; it should be -13±1 dBm.

g. Slowly decrease the signal generator output level until the power meter indication drops 1 dB. Note the signal generator output level; it should be -53±3 dBm.

h. If the indications of steps f and g are obtained, the 21 MHz amplifier/limiter is functioning properly; disconnect the test equipment, connect plug A2P4 to jack A2A1J1 and connect plug A2W1P1 to jack A2A2J2. If these indications are not obtained, continue to paragraph 4-56.

4-56. Troubleshooting and Alignment.

a. Using a Simpson 260 VOM, measure the voltage between pins 2 and 3 of plug A2P1; it should be +12 volts. If this indication is not obtained, check the +12 volt distribution lines.

b. Measure the voltage between pins 1 and 3 of plug A2P1; it should be -12 volts. If this voltage is not obtained, check the -12 volt distribution lines.

c. De-energize the RF-3000, remove the four screws that secure the assembly to the casting and carefully withdraw 21 MHz amplifier/limiter A2A1.

d. Energize the RF-3000 and, with the PHASE LOCK pushbutton switch depressed, measure the voltages at transistors A2A1Q1 and A2A1Q2 (see table 4-9); perform the necessary repairs or replacements.

e. Setup the equipment as indicated in paragraph 4-39 and illustrated in figure 4-20, but set the VERTICAL SENSITIVITY of the oscilloscope to .2V/cm, the FREQUENCY MEGACYCLES control of the sweep generator for an indication of 20, and omit attenuator 2. Instead, connect the input to attenuator 2, as shown, to the output of attenuator 1.

f. With the sweep generator disconnected from the oscilloscope SCOPE VERT jack, position the trace on the bottom CRT graticule horizontal line; then connect the sweep generator to the SCOPE VERT jack.

g. Adjust the sweep generator for an indicated output level of 1.2 volts (6 divisions high).

h. Set the HP-355D step attenuator for 40 dB insertion and insert 21 MHz Amplifier/Limiter A2A1 into the setup of figure 4-20 in the position of attenuator 2. (Connect the cable from the step attenuator to jack A2A1J1 and connect plug A2W1P2 to the cable going to the detector.)

i. Adjust capacitor A2A1C1 for best symmetry about the 21 MHz marker.

j. Alternately adjust inductors A2A1L2 and A2A1L3 for best symmetry about the 21 MHz marker.

k. Insert an additional 10 dB of attenuation (50 dB total) with the HP-355D step attenuator.

l. Alternately adjust capacitor A2A1C1 and indicator A2A1L3 for best symmetry about the 21 MHz marker.

m. Set the HP-355D step attenuator for 40 dB insertion and repeat step l.

n. Repeat steps k, l and m.

o. Disconnect the equipment from the setup of figure 4-20.

p. Tune on HP-608F signal generator for a cw output at 21 MHz and adjust for minimum output level. Couple an HP-478A thermistor mount and HP-432A power meter to A2W1P2.

q. Increase the signal generator output level to -30 dBm and note the power meter indication; it should be -13±1 dBm.

r. Decrease the signal generator output level until the power meter indication drops 1 dB; the signal generator level should be -53±3 dBm.

s. De-energize the RF-3000, disconnect the test equipment and install 21 MHz amplifier/limiter A2A1 into assembly A2. Connect plug A2P4 to jack A2A1J1 and connect plug A2W1P2 to jack A2A3J1. Replace the cover plate to casting A2.

4-57. PHASE DETECTORS A2A3.

4-58. Checkout.

Note

This procedure assumes that 21 MHz reference oscillator A2A2 and 21 MHz amplifier/limiter A2A1 have been checked per paragraphs 4-52 and 4-55, respectively, and are operating properly.

a. Tune an HP-608F signal generator for a cw output of 0 dBm at 21 MHz.

b. Set the controls of a Tektronix 545A oscilloscope (with a type CA plug-in) as directed in step b of paragraph 4-52.

c. Disconnect the plug from jack A2J1 and couple the output of the signal generator to jack A2J1.

d. With the RF-3000 unenergized, connect the ground lead of a Tektronix 1:1 probe to chassis ground; connect the probe tip to filter A2FL5.

e. Energize the RF-3000 and depress the PHASE LOCK pushbutton switch.

f. Note the oscilloscope display; a sinusoidal waveform having a peak-to-peak amplitude of at least 500 millivolts should appear.

g. Connect the probe to filter A2FL4 and again note the oscilloscope display; a sinusoidal waveform having a peak-to-peak amplitude of at least 150 millivolts should appear.

h. If the indications of steps f and g are obtained, the phase detectors are functioning properly; disconnect the test equipment and connect the proper plug to jack A2J1. If both indications are not obtained, proceed to paragraph 4-59.

4-59. Troubleshooting and Alignment.

a. Perform step a of paragraph 4-52.

b. With the RF-3000 energized and the PHASE LOCK pushbutton switch depressed, measure the voltage (using a Simpson 260 VOM) between pins 1 and 2 of plug A2P3; it should be +12 volts. If this voltage is not present, check the +12 volt distribution lines.

b. De-energize the RF-3000, remove the four screws that secure phase detectors A2A3 to casting A2. Carefully withdraw phase detectors A2A3. Check the assembly and replace and defective components.

c. Energize the RF-3000 and, with the PHASE LOCK pushbutton switch still depressed, check the voltages at A2A3Q1 (see table 4-11). Effect the necessary repairs and/or replacements.

d. Perform steps a through d of paragraph 4-58. Tune inductor A2A3L1 to obtain a maximum amplitude display; it should be greater than 500 millivolts peak-to-peak.

e. De-energize the RF-3000, disconnect the test equipment, connect the proper plug to A2J1 and replace the cover plate.

4-60. SIGNAL IDENTIFIER.

4-61. Checkout.

a. On the RF-3000 set the FREQUENCY DISPERSION control to 300 kHz/DIV.

b. On the Main Frame set the MARKER MODULATION to 1 MHz, and the BANDWIDTH control to 300 kHz.

c. Press the SIGNAL IDENTIFIER pushbutton; note that the signal moves 1 MHz to the left. If the signal fails to move precisely 1 MHz, perform the procedures of paragraph 4-62.

4-62. Alignment.

a. With the SIGNAL IDENTIFIER pushbutton in the depressed position, adjust the SIG IDENT ADJ control (located on the base of the chassis just behind the pulled oscillator) to position the signal 1 MHz to the left.

b. Connect an HP-608F signal generator to the RF-3000 and apply any band 1 signal such as 300 MHz.

c. On the main frame set the MARKER MODULATION to EXT.

d. On the RF-3000 set the FREQUENCY DISPERSION to 1 MHz/DIV with the concentric inner knob fully clockwise in the cal position.

e. Press the SIGNAL IDENTIFIER pushbutton; note that the signal is displaced to the left by 1 division (the UNCAL lamp does not go on). If the desired results are not obtained perform the dispersion alignment procedures of paragraph 4-35.

4-63. REMOVAL AND REPLACEMENT PROCEDURES.

4-64. RF/1F SHELF A1.

a. Disconnect the following coaxial cable plugs from their mating receptacles.

Connector	Mating Receptacle
W1P1	V3-B
W2P1	V3-A
W3P2	A1K1J1 (NC)
A1W16P2	A1HY1 (1)
W5P1	A1AT5J1
A13W1P1	A1AT6J1
P5	A1A2J2

b. Disconnect plug P1 from jack A1J1.

c. While facing the RF-3000 front panel, remove the three screws that secure RF/IF shelf A1 to both the main chassis and phase lock bracket A12. (The screw that secures RF/IF shelf A1 to the main chassis is located at the rear and to the right of 160 MHz preamplifier/amplifier assemblies A1A1/A1A2; the two that secure RF/IF shelf A1 to phase lock bracket A12 are located in the circular cutout at the front right of A1A1/A1A2 and behind circulator A1HY1.)

d. Remove the three flathead screws that secure A1 to the upper right frame bar.

e. Withdraw assemblies A3, A5, A6 and A9 from the RF-3000.

f. Remove the six screws and washers that secure RF/IF shelf A1 to right printed circuit board mounting plate. Note that the bottom three screws can be reached through the access holes in the left printed circuit board mounting plate.

g. Carefully lower the right side of RF/IF shelf A1 and slide it out of the RF-3000.

h. Replace assemblies A3, A5, A6 and A9 into their proper slots.

i. To replace RF/IF shelf A1, follow the reverse of steps h through a.

4-65. SECOND MIXER/160 MHZ PREAMPLIFIER A1A1 AND 160 MHZ BAND-PASS FILTER/ AMPLIFIER A1A2.

a. Disconnect plug A1A3P1 from jack A1CP5J2.

b. Disconnect coaxial couplers A1CP3 and A1CP5 from jacks A1A1J1 and A1A1J2, respectively.

c. Disconnect cable A1W8 from between jack A1A1J3 and jack A1A2J1.

d. Disconnect plug P5 from jack A1A2J2.

e. Remove the four screws and associated washers that secure both 160 MHz preamplifier A1A1 and 160 MHz amplifier A1A2 to RF/IF shelf A1.

f. Remove the top cover plate and the plate that separates 160 MHz preamplifier A1A1 and 160 MHz amplifier A1A2.

g. If complete removal of A1A1 is desired, unsolder the two blue leads from filter A1A1FL4 (the filter on the right side of A1A1 nearest the rear panel) and then unsolder the white/orange lead from filter A1A1FL3 (the filter opposite A1A1FL4). If complete removal of 160 MHz amplifier A1A2 is desired, unsolder the blue lead from filter A1A2FL1.

h. To replace 160 MHz preamplifier A1A1 or 160 MHz amplifier A1A2, follow the reverse of steps g through a.

4-66. SECOND LOCAL OSCILLATOR A1A3.

a. Disconnect plug A1A3P1 from jack A1CP5J2.

b. Disconnect plug A1W10P2 from jack A1CP3J2.

c. Unsolder the three leads (two white/gray; one white/blue) from the ground lug of second local oscillator A1A3. Tape the ends of these leads together.

d. Unsolder the blue lead from the top filter. Tape the end of this lead.

e. Unsolder the white/violet lead from the bottom filter. Tape the end of this lead.

f. Remove the four nuts and washers that secure the retaining brackets to RF/IF shelf A1. Remove the brackets and withdraw second local oscillator A1A3.

g. To replace second local oscillator A1A3, follow the reverse of steps f through a.

4-67. RADIAL LINE MIXER A1A4.

a. Disconnect plug A1W1P2 from jack A1A4J1.

b. Disconnect plug A1AT2 from jack A1A4J2.

c. Disconnect plug A1W6P1 from jack A1A4J3.

d. Loosen the locknut that secures coaxial coupler A1A4CP1 to radial line mixer A1A4. Unscrew coaxial coupler A1A4CP1 and withdraw diode A1A4CR1 from the mixer.

e. Grasping radial line mixer A1A4 from the underside of RF/IF assembly A1, remove the two screws and washers that secure the mixer to A1. Carefully withdraw the mixer.

f. To replace radial line mixer A1A4, follow the reverse of steps e through a.

4-68. 4 GHZ PRESELECTOR A1FL4.

a. Disconnect plug A1W7P1 from jack A1FL4J1.

b. Remove the two screws and washers that secure 4 GHz preselector A1FL4 and its mounting bracket to RF/IF shelf A1.

c. Unscrew plug A1FL4P1 from jack A1FL3J1.

d. Withdraw the preselector and bracket. To separate the preselector from its mounting bracket, remove the four screws that secure the two together.

e. To replace the filter, follow the reverse of steps d through a.

4-69. 5 GHZ LOW-PASS FILTER A1FL3.

a. Perform steps b and c of paragraph 4-68.

b. Unscrew plug A1FL3P1 from jack A1CP2J1.

c. Withdraw the filter.

4-70. 2.08 GHZ PRESELECTOR A1FL7.

a. Remove 4 GHz preselector A1FL4 as detailed in paragraph 4-68.

b. Unscrew plug A1FL6P1 from jack A1FL7J1. Disconnect plug A1W13P1 from jack A1FL7J2. The 2.08 GHz preselector can now be checked and/or aligned.

c. If filter must be replaced, return unit to factory, do not attempt to remove the filter from the RF-3000.

4-71. 2 GHz LOW-PASS FILTER A1FL6.

a. Perform steps b and c of paragraph 4-68.

b. Disconnect plug A1W12P2 from jack A1FL6J1.

c. Unscrew plug A1FL6P1 from jack A1FL7J1.

d. Remove the filter.

4-72. 3.84 GHZ PRESELECTOR A1FL5.

a. Disconnect plug A1W10P1 from jack A1FL5J2.

b. Remove frequency doubler A1A5 (refer to paragraph 4-73).

c. Disconnect plug A1CP3 from jack A1A1J1.

d. Remove the two screws that secure the preselector and its mounting bracket to RF/IF shelf A1. To separate the preselector from the mounting bracket, remove the four screws that secure the two together.

4-73. FREQUENCY DOUBLER A1A5.

a. Disconnect plug A1W9P2 from jack A1A5J1.

b. Disconnect plug A1W13P2 from jack A1CP5J1.

c. Disconnect plug A1W7P2 from jack A1CP3J1.

d. Unscrew plug A1A5P1 from jack A1FL5J1.

e. Lift frequency doubler A1A5 from its mounting clips.

4-74. CIRCULATOR A1HY1.

a. Disconnect plug A1W15P1 from jack A1HY1J3.

b. Disconnect plug A1W16P2 from jack A1HY1J2.

c. Disconnect plug A1W14P2 from jack A1HY1J1.

d. Remove the two cross-recessed screws from the supporting L-shaped bracket.

e. Lift out circulator A1HY1 from the top of the RF-3000.

4-75. PRINTED CIRCUIT BOARDS A3 THROUGH A9.

a. Withdraw the appropriate printed circuit board assembly from its mounting within the RF-3000.

b. Withdraw the accessory extender board from its mounting along the right side of the RF-3000.

c. Install the extender board into the receptacle vacated by the removal of the printed circuit board. Install the printed circuit board atop the extender board.

4-76. 29 MHZ PULLED OSCILLATOR A11.

a. Remove the PHASE LOCK ADJUST knob.

b. Remove the plug attached to the purple and black power cable from the socket behind the pulled oscillator.

c. Loosen and remove the cross-recessed head screw on the front panel adjacent to the PHASE LOCK ADJUST knob.

d. Remove the shaft retaining nut of the PHASE LOCK ADJUST knob shaft.

e. Disconnect plug A12W4P1 from jack A11J1 as 29 MHz pulled oscillator A11 is removed from the bottom of the RF-3000.

4-77. PHASE LOCK BRACKET A12.

a. Disconnect plug W4P2 from jack A12A1J1.

b. Disconnect plug W5P2 from jack A12DC1J2.

c. Disconnect plug W6P1 from jack A12A2J1.

d. Remove the four cross-recessed head screws supporting the L-shaped aluminum support bracket.

e. Remove phase lock bracket A12 from the bottom of the RF-3000.

4-78. RF STEP ATTENUATOR AT1.

a. Remove the front panel knob from the end of the attenuator shaft.

b. Carefully disconnect the rigid coaxial cable from the output jack of the attenuator.

c. Remove the three flathead screws that secure the attenuator to the rear of the front panel.

d. Remove the attenuator through the bottom of the RF-3000.

4-79. FRONT PANEL. To gain access to the components and assemblies mounted on the rear of the front panel assembly, proceed as follows.

a. With the RF-3000 removed from line power and placed upside-down, disconnect plug P1 of semi-rigid coaxial cable W3 from the output jack of step attenuator AT1.

b. Disconnect plug P1 of semi-rigid coaxial cable A1W16 from the output jack of bias T CP2.

c. Disconnect plug A11P1 from jack J12. Disconnect plug W4P1 from jack A11J1.

d. Remove the eight screws that secure the front panel to the chassis.

e. Carefully pull the front panel forward. The components and assemblies mounted on the front panel will now be visible and accessible.

4-80. TUNING CONTROL R5.

a. Remove the front panel from the RF-3000 as directed in paragraph 4-79.

b. Loosen the two setscrews that secure the PHASE LOCK ADJUST control knob to the shaft of A11C1. Remove the knob.

c. Remove the hex nut that secures capacitor A11C1 to the front panel. Remove the screw (beside the shaft of A11C1) which secures 29 MHz pulled oscillator A11 to the front panel. Carefully place 29 MHz pulled oscillator A11 to one side; the coupling between the TUNING control and R5 will now be visible.

d. Rotate the TUNING control fully counterclockwise and then one-half turn clockwise. The flat on the shaft of R5 should be facing up.

e. Unsolder the red, white and black leads from the terminals of R5.

f. Holding the TUNING control to prevent rotation, loosen the hex nut that secures R5 to the dial casting. R5 to the dial casting.

g. Loosen the two setscrews that secure the shaft of R5 to the coupler.

h. Holding the TUNING control to prevent rotation, withdraw it from the coupler (catching the hex nut and washer as they fall from the shaft) and casting.

i. Rotate the shaft of the replacement potentiometer fully counterclockwise and then one-half turn clockwise.

j. Insert the shaft of the replacement pot through the mounting hole of the casting. Place the washer and hex nut (in that order) on the shaft and then continue insertion until the shaft engages the coupler. When completely engaged, tighten the hex nut (the terminals of the replacement potentiometer should be facing tuning limit control A10.

k. Tighten the two setscrews to secure the coupler to the shaft of the pot.

l. Solder the white lead (of the cable assembly removed in step e) to the terminal furthest from the front panel, solder the white lead to the center terminal and the black lead to the terminal closest to the front panel.

m. Replace 29 MHz pulled oscillator A11.

n. Replace the front panel.

o. Align the BWO frequency as directed in paragraph 4-35.

4-81. BWO V3. The replacement procedure for BWO V3 is detailed in paragraph 4-83. If the warranty period for the tube has elapsed and the tube operates normally except for low output power, the output power level of the BWO can be increased by raising the anode voltage. This procedure, given in paragraph 4-82, extends the useful life of the tube.

4-82. Out-of-Warranty Tube Life Extension.

a. With the RF-3000 removed from line power, disconnect cable W1P2 from its mating connector on 8 GHz low-pass filter A1FL1.

b. Connect cable W1P2 (through a TNC male-to-female adapter and a Narda 777T-20 20 dB pad) to a thermistor mount. Couple the thermistor mount to an HP-432A power meter.

c. Set the RF-3000 RANGE switch to .01-3.5 GHz and depress the 0 dispersion pushbutton switch.

d. Place the probe of an HP-428B clip-on milliammeter around the brown (helix) lead of the BWO.

e. Couple the RF-3000 to line power, depress both the SYSTEM POWER and LO ENABLE pushbutton switches and after 10 minutes of warmup, slowly rotate the TUNING control throughout its range (pointer indications from .01 GHz to second dot to the right of 3.5 GHz). Note and record the low power frequency.

f. Set the TUNING control to the low power frequency.

CAUTION

Do not exceed a helix current of 30 milliamperes.

g. While monitoring the helix current level indicated by the clamp-on milliammeter, adjust potentiometer A6R18 to obtain a power meter indication of 0.3 milliwatts.

h. Rotate the TUNING control throughout its range as in step e. Note both the power meter and clip-on milliammeter indications; if they both drop abruptly to zero and remain there (particularly near the low frequency end of the band), excessive anode current is being drawn and the tube must be replaced. If, however, output power is obtained throughout the band, de-energize all equipment, remove the RF-3000 from line power, connect W1P2 to A1FL2 and proceed to paragraph 4-35.

4-83. Replacement.

NOTE

BWO V3 is a product of Varian Associates and is warranted by the manufacturer for 2500 hours or one year of heater operation, whichever comes first. If the BWO fails within this warranty period, see the In-Warranty Claim Form at the rear of this manual.

Remove total time indicator A5TT1 and return with the BWO when making BWO in-warranty adjustment.

a. Remove SPA-3000 from line power. With the top, bottom and side covers of the RF-3000 removed, disconnect plug P2 from jack J1.

b. Place the RF-3000 upside-down. Disconnect plug W1P1 from port B of V3; disconnect plug W2P1 from port A.

c. Loosen and remove the four screws that secure the smaller of the two phenolic high voltage covers to its mounting studs. Remove the cover.

d. Unsolder the brown/white lead (that going to the harness) from filter A2FL1.

e. Unsolder the purple lead from filter A2FL2.

f. Unsolder both resistor R6 and capacitor C10 from filter A2FL5.

g. Unsolder the grey/white lead from filter A2FL4.

h. Disconnect plug W6P2 from jack A2J1.

i. Loosen and remove the two screws that secure the BWO to the RF-3000 chassis. These screws are accessible through the two holes of the high voltage divider component board.

j. Loosen and remove the five screws that secure BWO V3/phase lock casting A2 to the RF-3000 chassis. Carefully slide the BWO/phase lock casting approximately 1/2 inch toward the front panel. Grasp both ends of the casting and lift the combined assembly from the RF-3000.

k. Loosen and remove the two screws that secure the BWO to the phase lock casting.

l. Refer to the In-Warranty Claim Form at the rear of this manual for instructions on shipping the BWO.

m. Note the following data for the replacement BWO:

(1) Rated anode voltage,

(2) Rated helix voltage @ 4 GHz,

(3) Rated helix voltage @ 8 GHz.

n. To replace the BWO, follow the reverse of steps k through d.

o. Install replacement total time indicator on -6.3 Volt BWO Filament Power Supply Assembly A5, positioning the gap at the $x10^3$ HRS scale 0 line.

4-84. 8 GHZ LOW-PASS FILTER A1FL1.

a. Disconnect plug A1W1P2 from plug A1FL1J1.

b. Unscrew filter A1FL1 from relay A1K1 and remove the filter from the RF/IF shelf.

4-85 4 GHZ NOTCH FILTER A1FL2.

a. Disconnect plug A1W3P2 from jack A1FL2J1.

b. Disconnect plug A1W4P1 from A1FL2J2.

c. Disconnect the two cross recessed screws from the top of the filter and remove from the top of the RF-3000.

4-86. 4 GHZ HIGH PASS FILTER A12FL1.

a. Disconnect plug A12W2P1 from jack A12FL1J2.

b. Disconnect plug A12W1P2 from jack A12FL1J1.

c. Remove the four filter bracket retaining screws and remove the filter from the top of the RF-3000.

4-87. PHASE LOCK CASTING A2.

a. Perform steps a through k of paragraph 4-83, and then proceed to step b.

b. Remove the four screws that secure the BWO mounting plate (with the BWO attached) to A2.

c. Remove the casting.

4-88. VOLTAGE MEASUREMENTS.

4-89. The voltage measurements for all active elements within the RF-3000 are listed in tables 4-7 through 4-21. Unless otherwise noted, all measurements were made with a vtvm with respect to chassis ground after the front panel controls have been set per table 2-2.

TABLE 4-7. VOLTAGE AND RESISTANCE MEASUREMENTS, MAIN CHASSIS

Reference Symbol Number	Tube Type	Pin Number									
		1	2	3	4	5	6	7	8	9	
V1[1]	8068	NC	FIL	FIL	NC	+75	NC	FIL	+740	-	ν
		-	280K	280K	-	330K	-	280K	180K	-	Ω
V2[1]	7239	-4	0	NC	FIL	FIL	+67	NC	NC	0	ν
		2.8K	0	-	0	0	25K	-	-	0	Ω

	Transistor Type	Emitter Voltage	Base Voltage	Collector Voltage	
Q1	2N3613	+18.3	+18	+12	
Q2	2N3613	+6.7	+6.4	0	

1. RANGE switch set to .01-3.5 GHz and TUNING control adjusted to obtain pointer indication of 2.

2. FIL = 6.3 VAC between pins indicated.

TABLE 4-8. VOLTAGE MEASUREMENTS, SECOND MIXER/160 MHZ PREAMPLIFIER A1A1 AND 160 MHZ BAND-PASS FILTER/AMPLIFIER A1A2

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	SE5020	-10.6	-10	0

TABLE 4-9. VOLTAGE MEASUREMENTS, 21 MHZ AMPLIFIER/LIMITER A2A1

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	A467	-0.69	0	+10.4
Q2	A467	-0.88	-0.28	+9.6

PHASE LOCK pushbutton switch S3 depressed.

TABLE 4-10. VOLTAGE MEASUREMENTS, 21 MHZ REFERENCE OSCILLATOR A2A2

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N3646	+4.7	+4.6	+11.9
Q2	2N3646	+2.0	+0.38	+7.2

PHASE LOCK pushbutton switch S3 depressed.

TABLE 4-11. VOLTAGE MEASUREMENTS, PHASE DETECTORS A2A3

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	A467	+2.5	+3.1	+9.6

PHASE LOCK pushbutton switch S3 depressed.

TABLE 4-12. VOLTAGE MEASUREMENTS, ±12 VOLT CONTROL A4

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N3638	+18	+17.7	+12
Q2	2N3638	+18	+17.7	+17
Q3	2N3694	+5.4	+5.7	+17.7
Q4	2N3694	+5.4	+5.7	+12
Q5	2N3638	+6.4	+6.0	0
Q6	2N3638	+6.7	+6.4	+5.8
Q7	2N3694	-6.2	-5.9	+5.8
Q8	2N3694	-6.2	-5.7	0

TABLE 4-13. VOLTAGE MEASUREMENTS, -6.3 VOLT BWO FILAMENT POWER SUPPLY A5

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N3055	-9.2	-8.6	-6.1
Q2	2N3646	-8.6	-8.0	-6.1
Q3	2N3638A	-3.5	-3.8	-8.0
Q4	2N3638A	-3.5	-3.8	-9.4

TABLE 4-14. VOLTAGE MEASUREMENTS, +180 VOLT/ANODE POWER SUPPLY A6

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	40327	+209.7	+210	+280
Q2	40327	+137.7	+138	+209.7
Q3	40327	+73.7	+74	+137.7
Q4	40327	+42.7	+43	+74
Q5	40327	+12.2	+12.8	+42.7
Q6	2N3904	+73.4	+73.7	+74
Q7	2N3904	0	+0.6	+12.8
Q8	2N3904	-2.8	-2.4	+0.3
Q9	2N3904	-2.8	-2.4	+0.6

LO ENABLE pushbutton switch S2 depressed.

TABLE 4-15. VOLTAGE MEASUREMENTS, SWEPT POWER SUPPLY CONTROL A7

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N3565	-8.0	-7.4	+11.4
Q2	2N3638A	-1.0	-1.6	-7.4
Q3	2N3638A	+4.7	+4.1	-1.6
Q4	2N3565	+4.1	+4.7	+11.4
Q5	2N3565	-0.6	0	+5
Q6	2N3565	-0.6	0	+5
Q7	2N3638	-0.5	-0.1	-12
Q8	2N3638	+9.5	+9.0	-0.1
Q9	2N3565	-0.6	0	+9.0
Q10	2N3565	-0.6	0	+9.5
Q11	2N3565	0	-5.6	+11.6
Q12	2N3638A	+3.2	+6	-5.6
Q13	2N3638A	+3.2	+2.6	+1.7
Q14	2N3638A	+0.05	+5.7	-11.7
Q15	2N3565	-1.8	-6	+5.7
Q16	2N3565	-1.8	-1.2	-1.7

MHZ/DIV pushbutton switch S8 depressed

TABLE 4-16. VOLTAGE MEASUREMENTS, AUXILIARY CONTROL A8

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N3565	-0.6	0	+10.8
Q2	2N3565	-0.6	-0.1	+6.0
Q3	2N3565	+5.4	+6.0	+10.8
Q4	2N3565	-1.2	-0.5	+2.4
Q5	2N3440	-1.2	-0.6	-1.1
Q6	2N3638	+0.4	-0.2	-7.2
Q7	2N3638	+0.4	-0.3	-0.4
Q8	2N3565	0	-5.8	+11.6
Q9	2N3638	+3.2	+6.6	-5.7
Q10	2N3638	+3.2	+2.6	+1.5
Q11	2N3638A	+12	+10.4	+11.3
Q12	2N3565	+8.4	+9.0	+10.4
Q13	2N3565	+8.4	+11.3	+11.3

RF MARKER pushbutton switch S4 depressed

TABLE 4-17. VOLTAGE MEASUREMENTS, -24 VOLT POWER SUPPLY A9

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N4918	-24	-23.4	-41
Q2	2N3906	-24	-23.4	-23
Q3	2N3906	-11.4	-12	-41
Q4	2N3906	-12	-11.4	-12

Reference Symbol Number	IC Type	Pin Number								
		1	2	3	4	5	6	7	8	-
MC1	μA709C	-5	-17	-16.4	-28	-27	-24	0	-4.4	
MC2	μA709C	-4	-3.8	-3.7	-23	-22	-12	0	-3.3	

TABLE 4-18. VOLTAGE MEASUREMENTS, TUNING UNIT CONTROL A10

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N5306	-24	-14	-25
Q2	2N3906	-14	-13.5	-24
Q3	2N3906	-14	-3.3	-3
Q4	2N3906	-14	-14.5	-24

RANGE switch set to .01-3.5 GHz and TUNING control set for a dial indication of 1.5 GHz

TABLE 4-19. VOLTAGE MEASUREMENTS, 29 MHZ PULLED OSCILLATOR A11

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N4917	-0.7	-1.8	-11.7

TABLE 4-20. VOLTAGE MEASUREMENTS, COMB GENERATOR A12A1

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	2N4427	-9.5	-10	0

TABLE 4-21. VOLTAGE MEASUREMENTS, 21 MHZ AMPLIFIER A12A2

Reference Symbol Number	Transistor Type	Nominal Voltage		
		Emitter	Base	Collector
Q1	A467	+3	+3.8	+11.4

SECTION V
SCHEMATIC DIAGRAMS

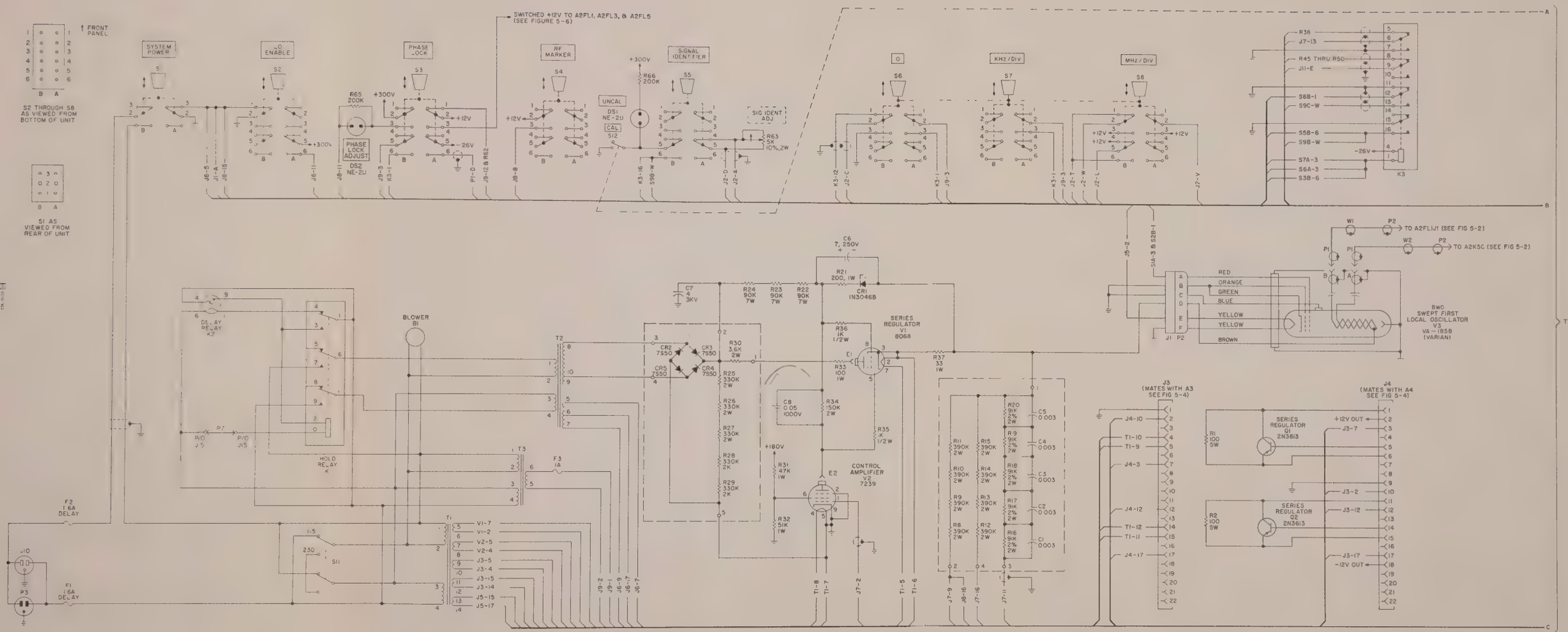


Figure 5-1. Model RF-3000 Tuning Head, Interconnecting Cabling Diagram (Sheet 1 of 2)

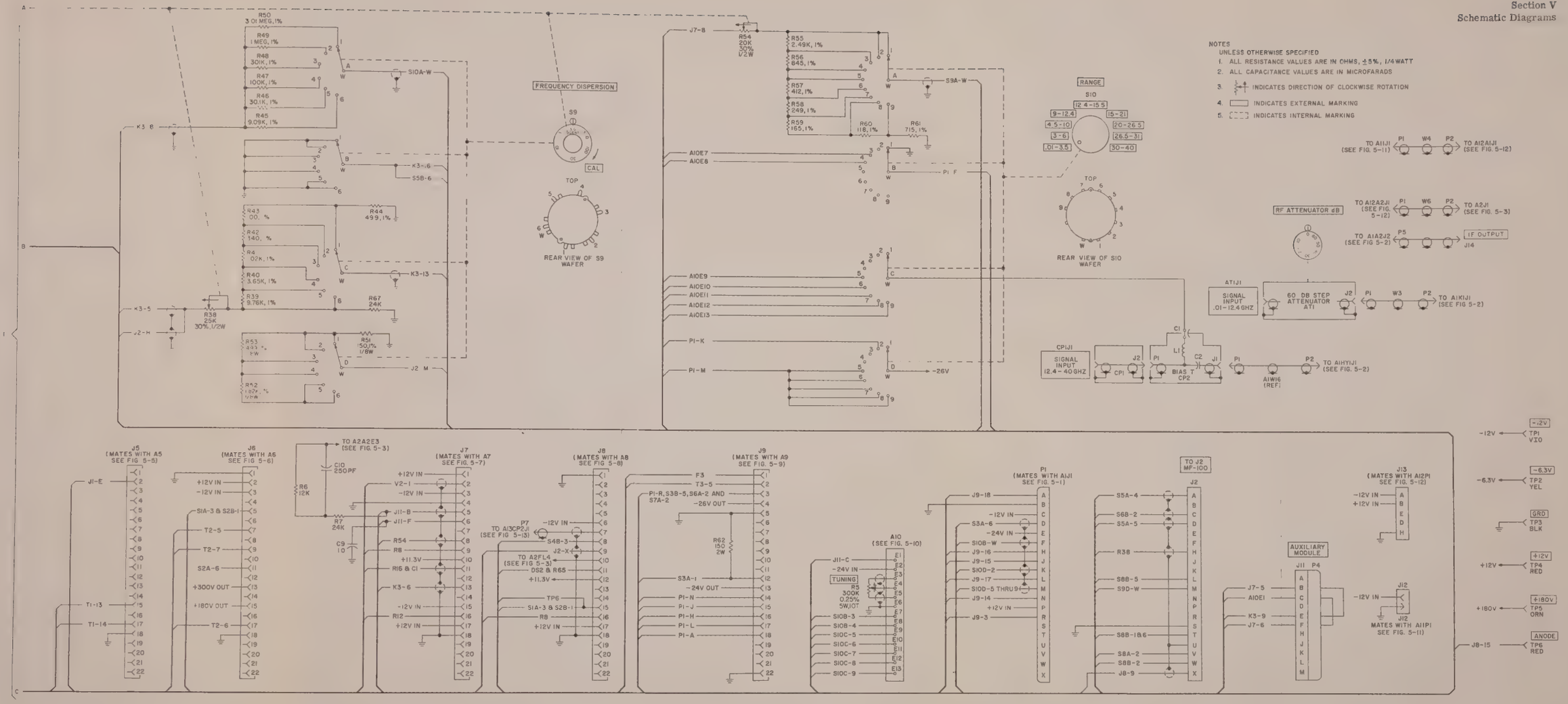


Figure 5-1. Model RF-3000 Tuning Head, Interconnecting Cabling Diagram (Sheet 2 of 2)

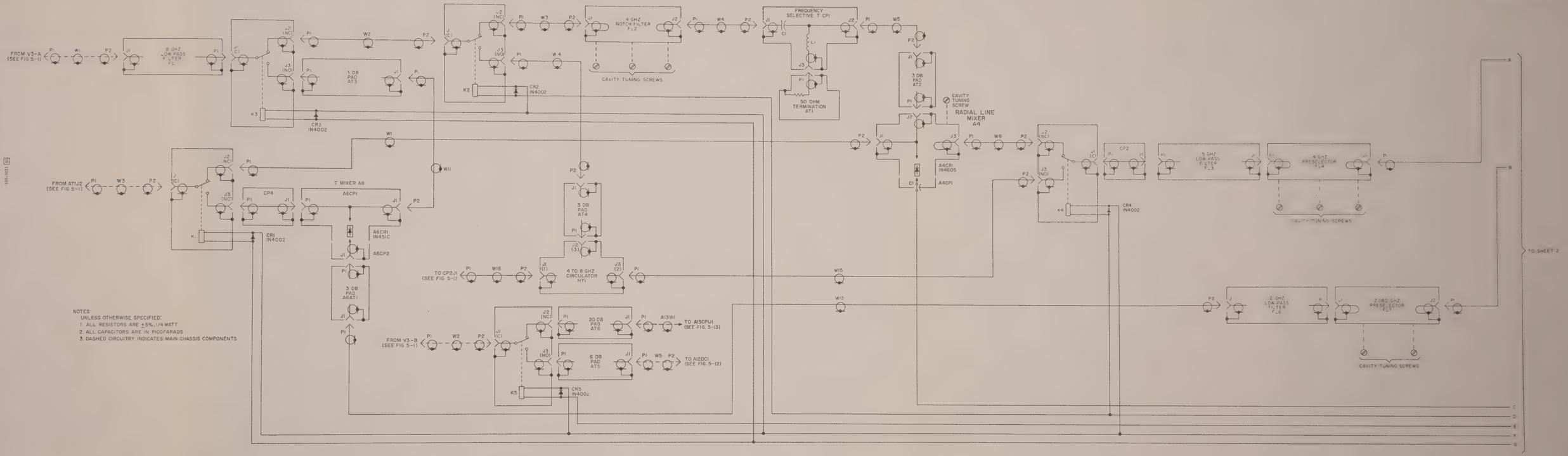


Figure 5-2. Rf II Shelf A1, Schematic Diagram (Sheet 1 of 2)

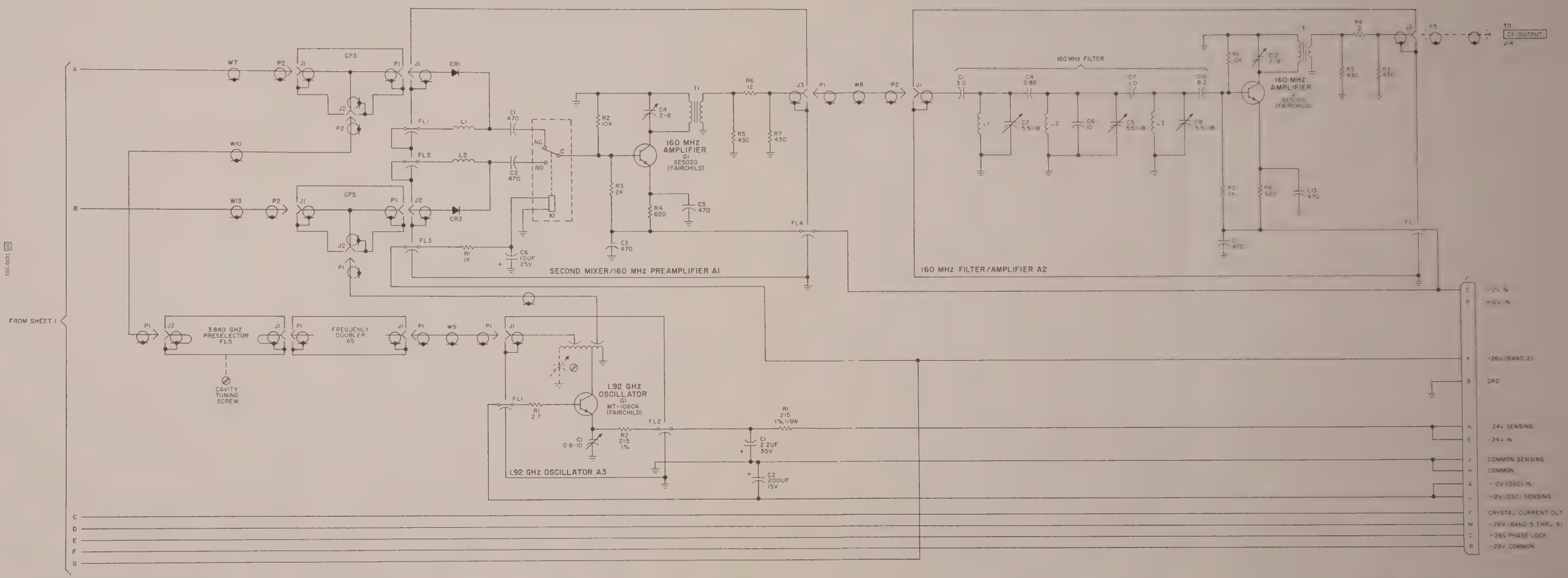
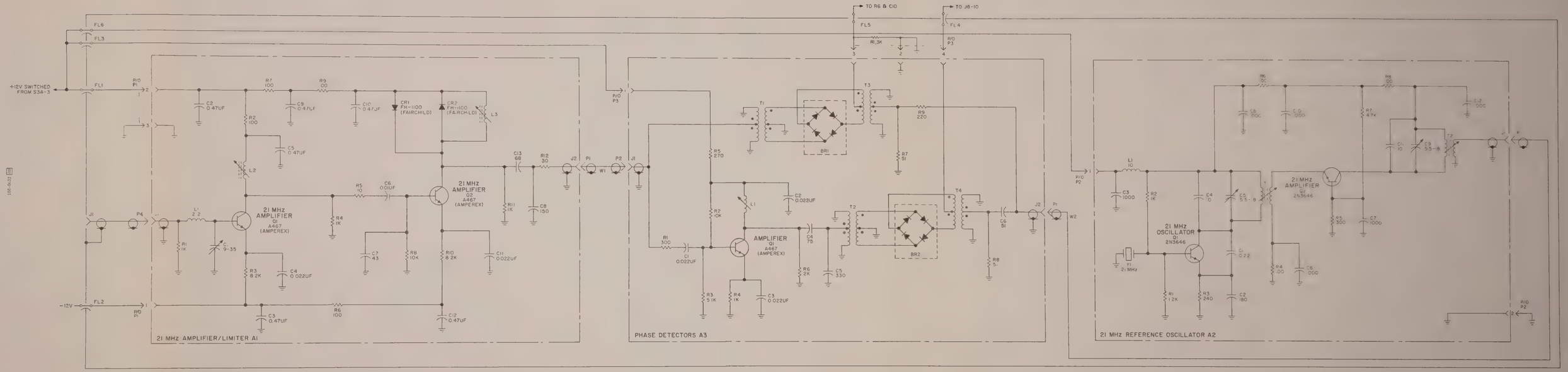


Figure 5-2. Rf If Shelf A1, Schematic Diagram (Sheet 2 of 2)



NOTES
UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE ±5%, 1/4 WATT
2. ALL CAPACITORS ARE IN PICOFARADS
3. ALL INDUCTORS ARE IN MICROHENRIES

Figure 5-3. Phase Lock Casting A3, Schematic Diagram

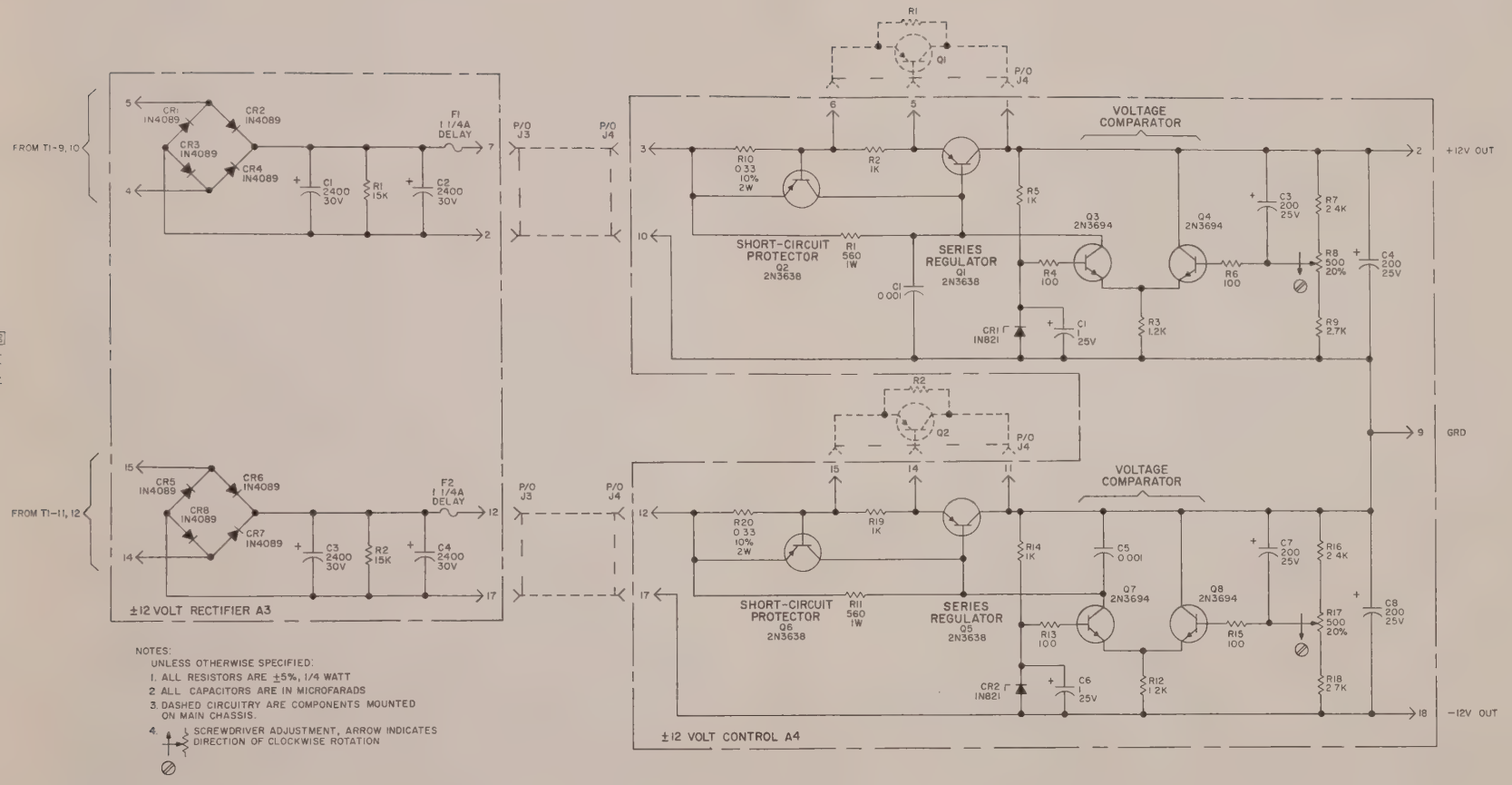
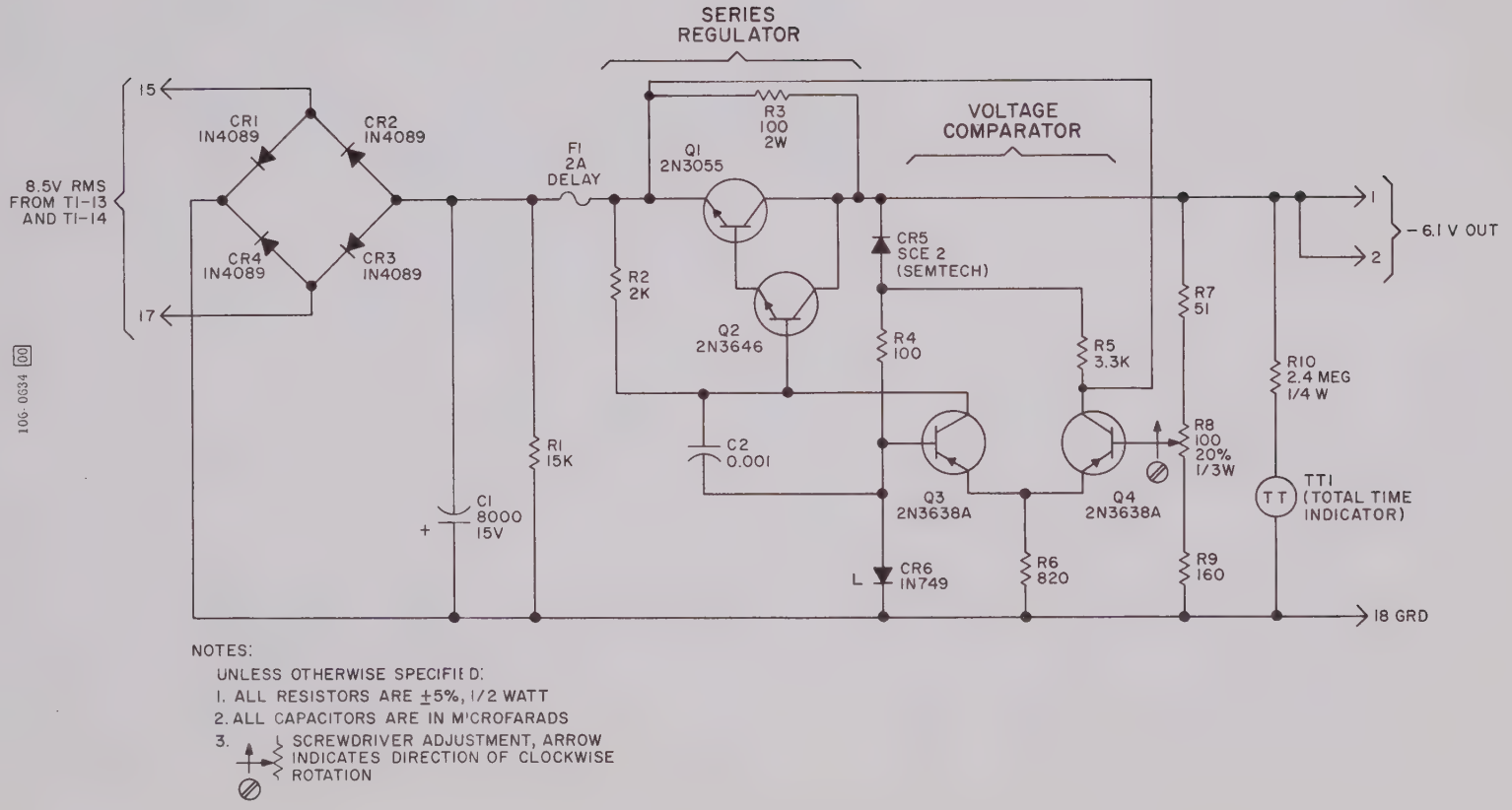


Figure 5-4. 12 Volt Rectifier A3 and ±12 Volt Control A4, Schematic Diagram



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE ±5%, 1/2 WATT
2. ALL CAPACITORS ARE IN MICROFARADS
3. SCREWDRIVER ADJUSTMENT, ARROW INDICATES DIRECTION OF CLOCKWISE ROTATION

Figure 5-5. -6.3 Volt BWO Filament Power Supply A5, Schematic Diagram

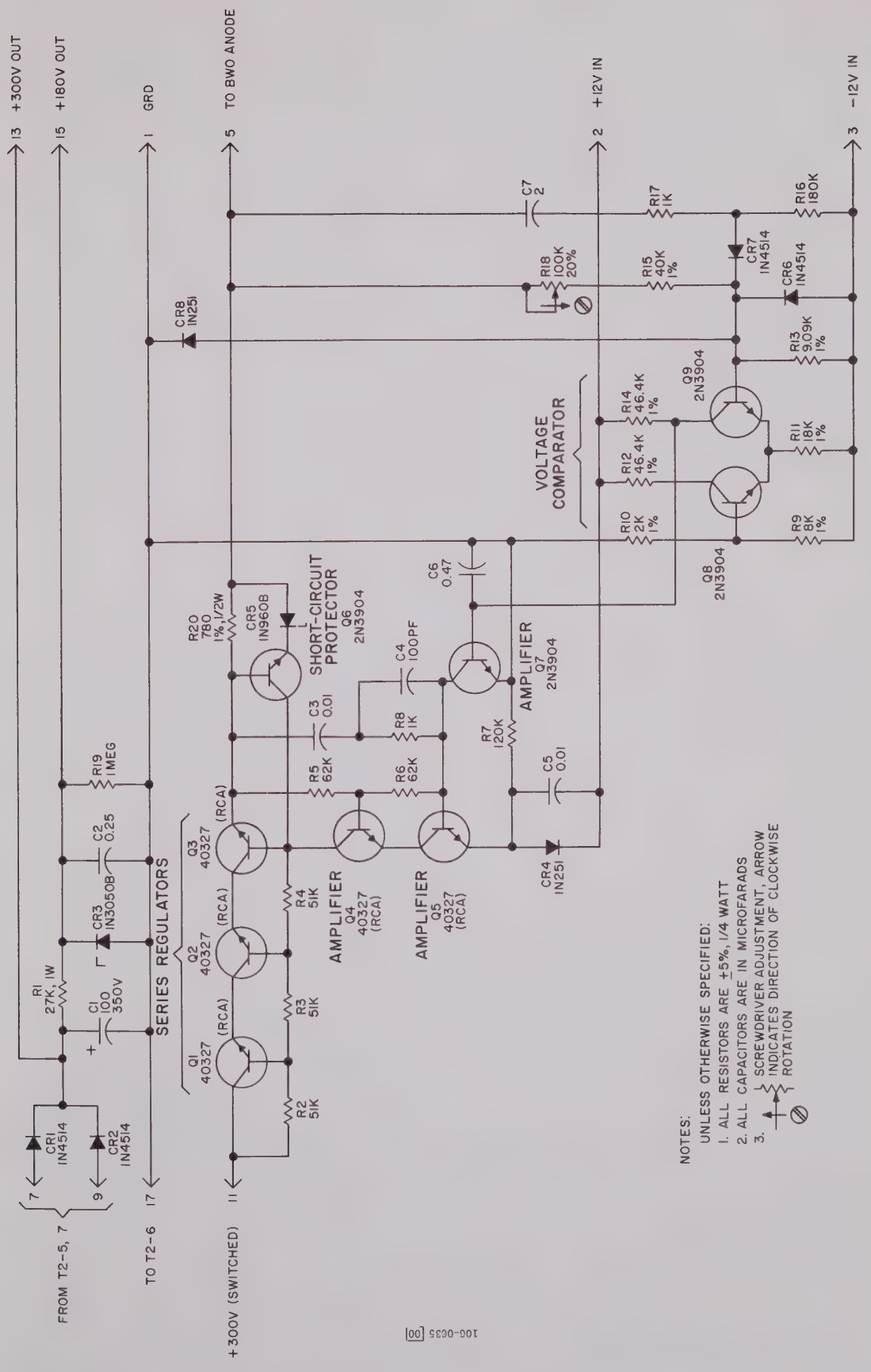


Figure 5-6. +180 Volt/Anode Power Supply A6, Schematic Diagram

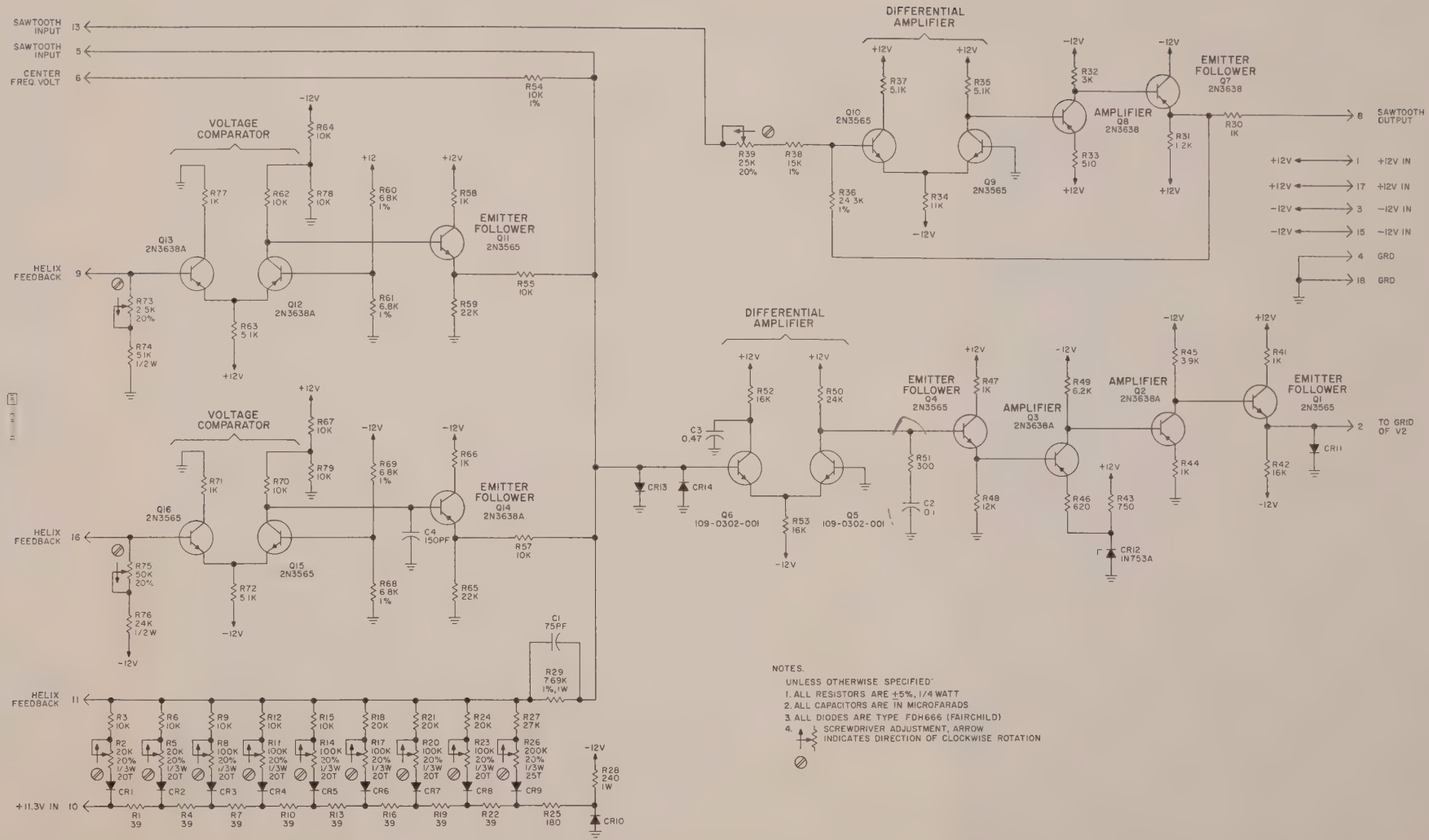


Figure 5-7. Swept Power Supply Control A7, Schematic Diagram

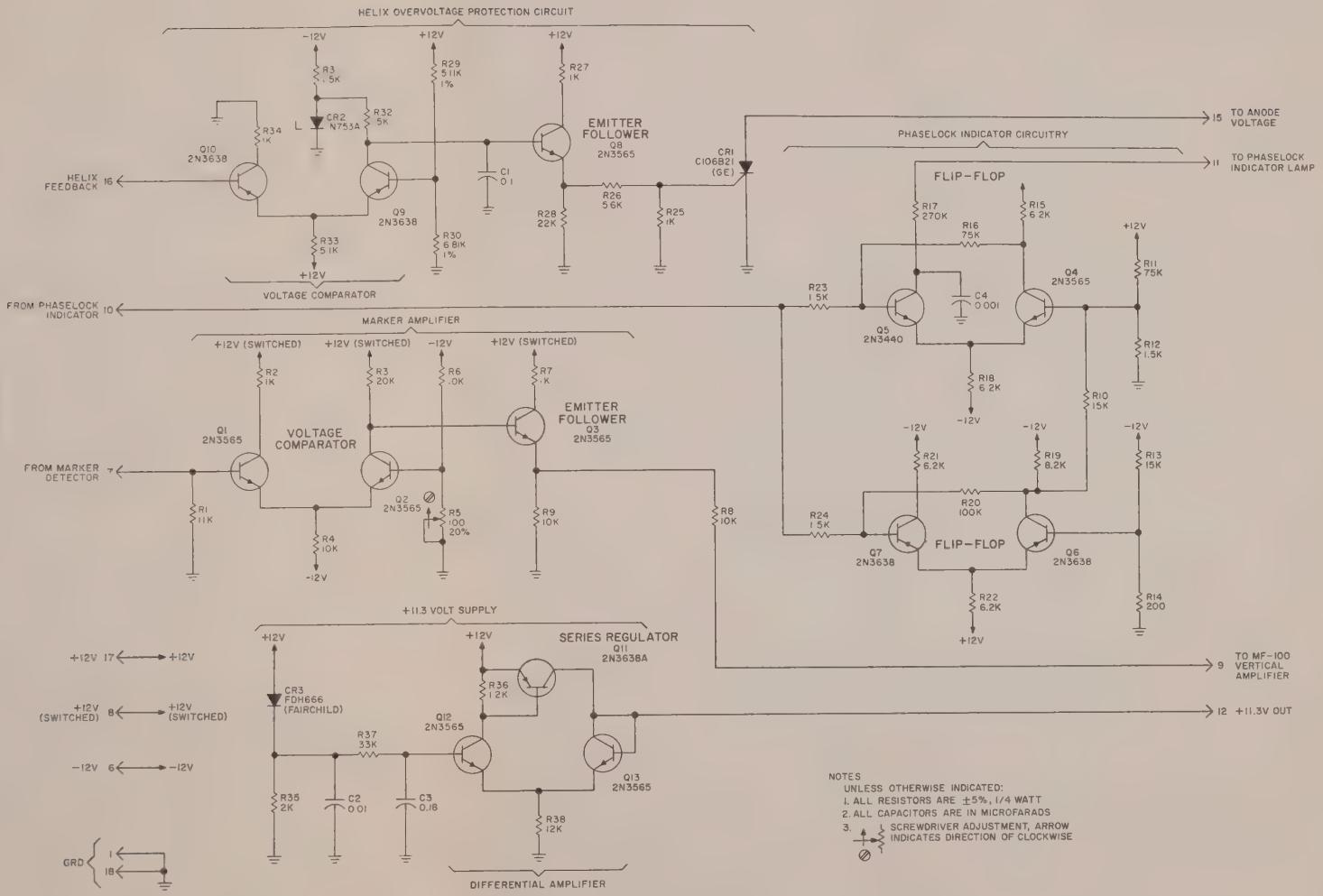


Figure 5-8. Auxiliary Control A8, Schematic Diagram

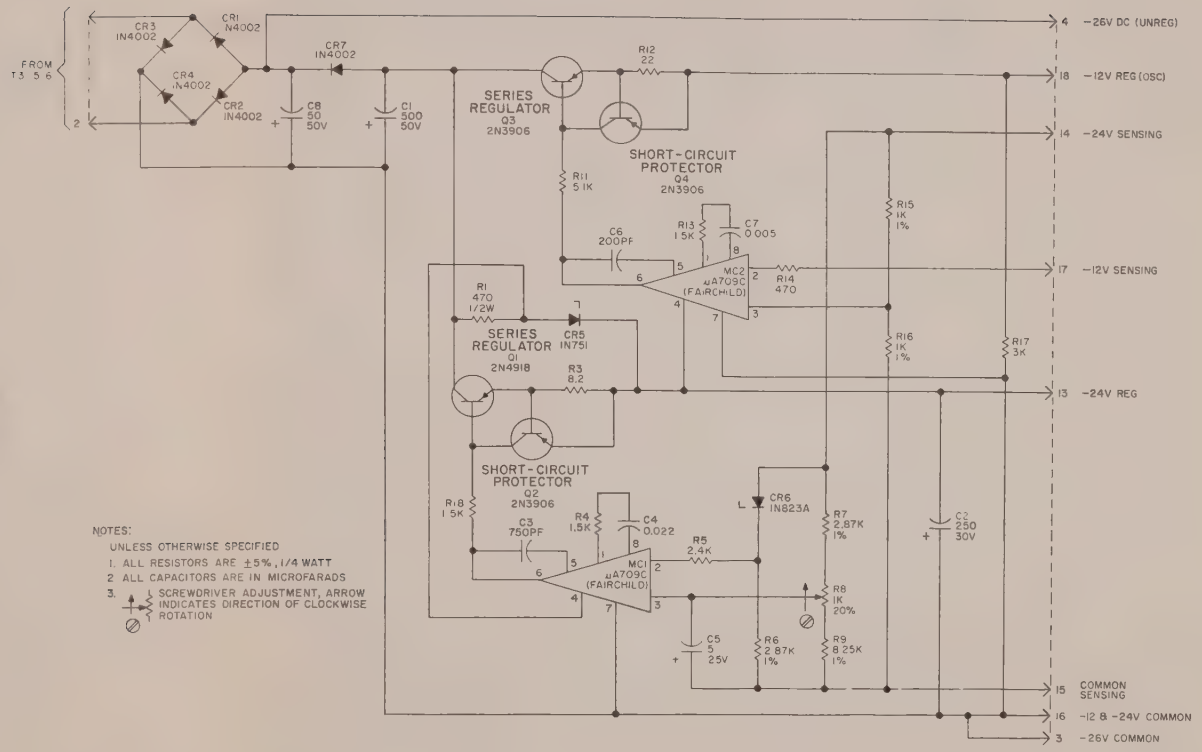


Figure 5-9. -24 Volt Power Supply A9, Schematic Diagram

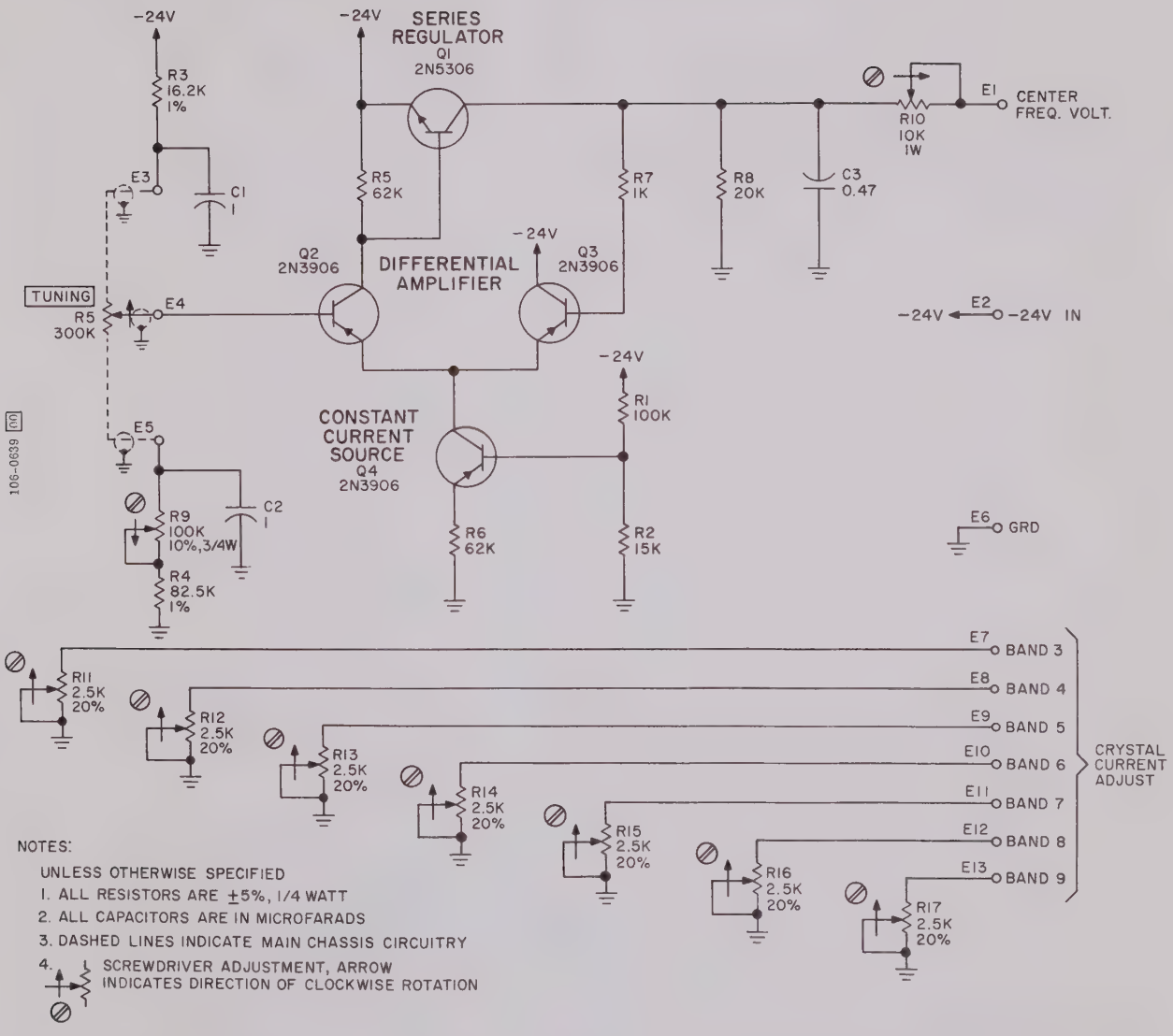
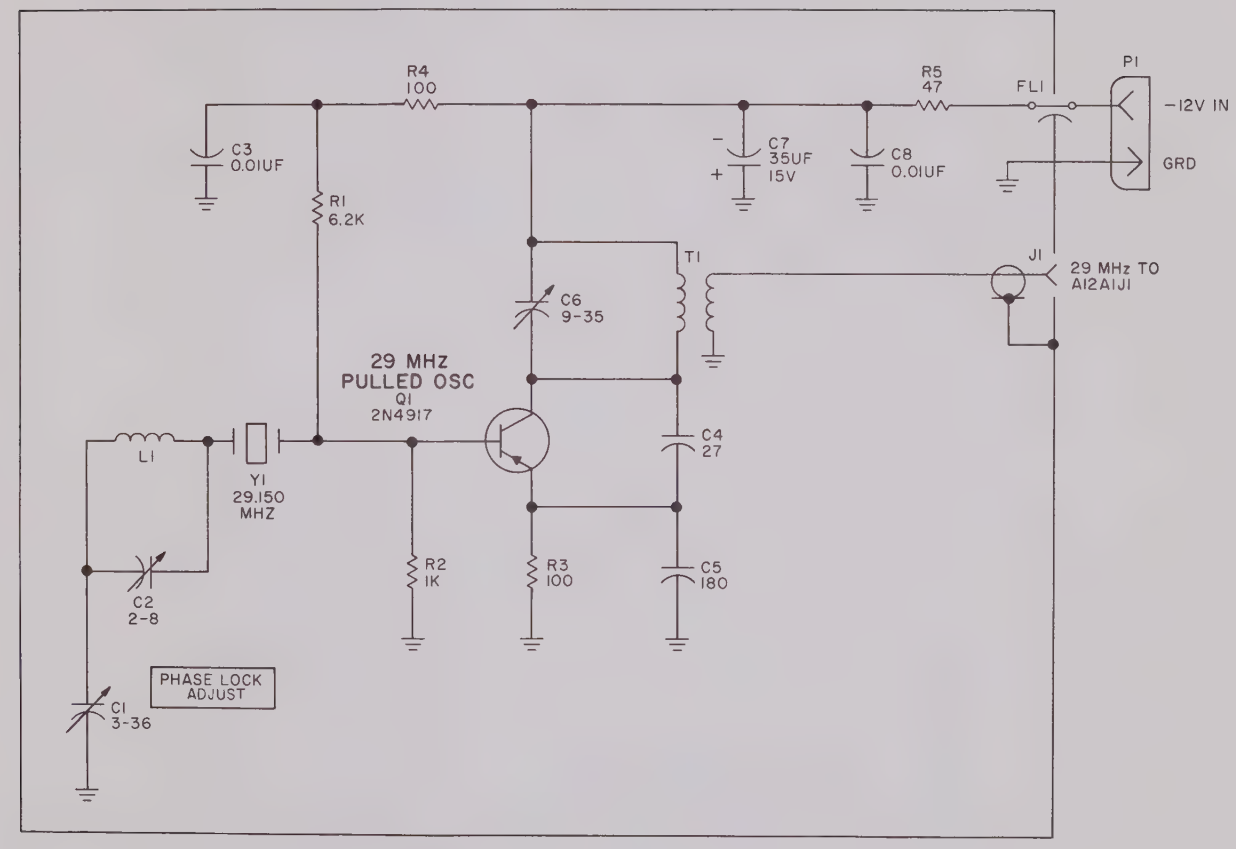
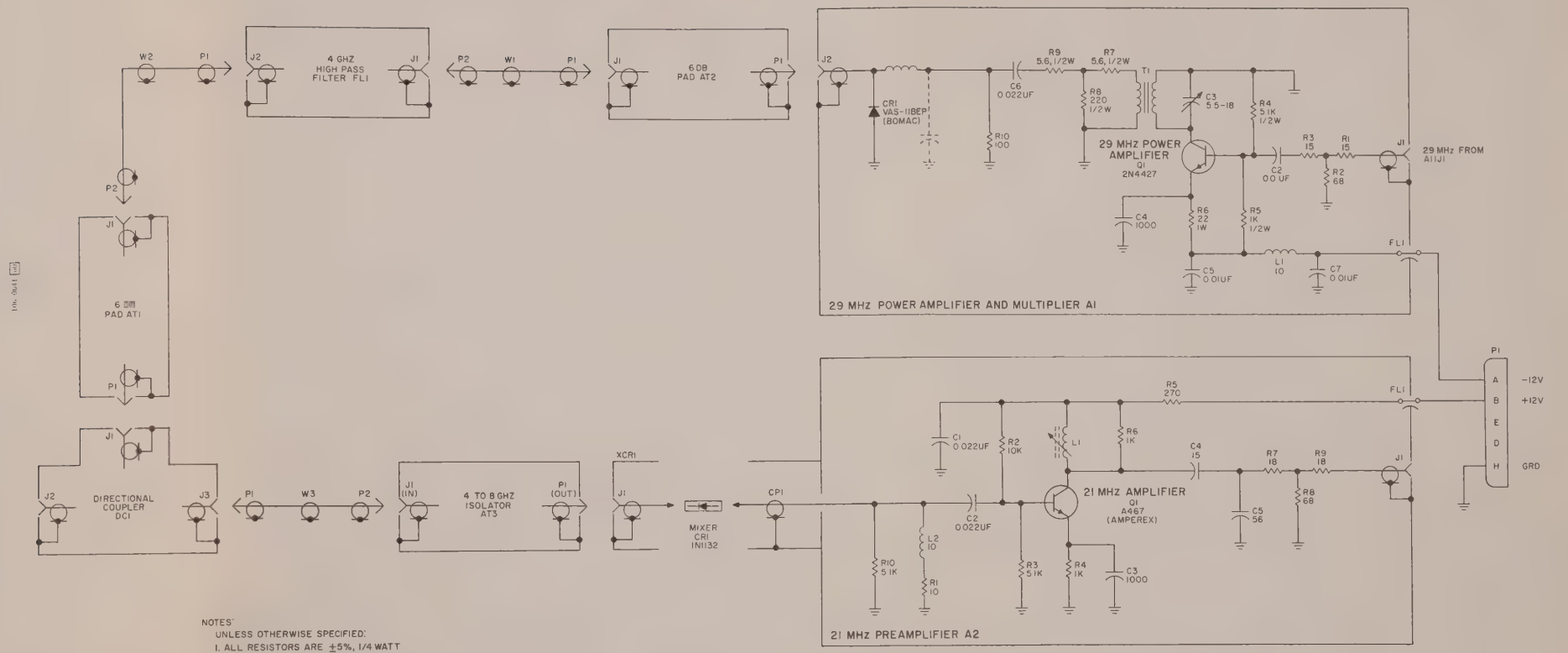


Figure 5-10. Tuning Limit Control A10, Schematic Diagram



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE ±5%, 1/4 WATT
2. ALL CAPACITORS ARE IN PICOFARADS
3. ▭ INDICATES FRONT PANEL MARKING

Figure 5-11. 29 MHz Pulled Oscillator A11, Schematic Diagram



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE ±5%, 1/4 WATT
2. ALL CAPACITORS ARE IN PICOFARADS
3. ALL INDUCTORS ARE IN MICROHENRIES

Figure 5-12. Phase Lock Bracket A12, Schematic Diagram

106-0642 00

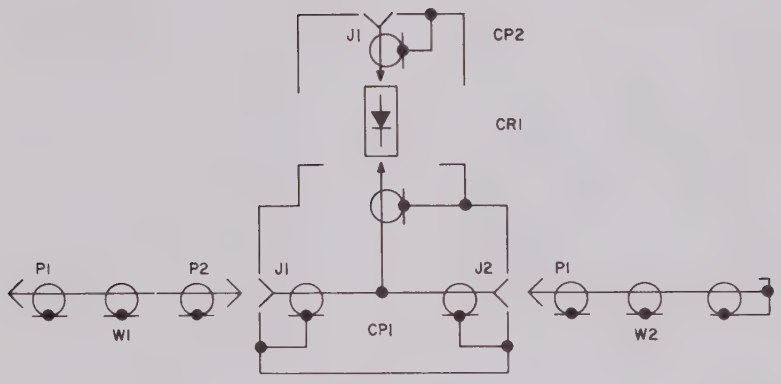


Figure 5-13. Rf Marker A13, Schematic Diagram

SECTION VI
PARTS LIST

6-1. INTRODUCTION

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION

6-4. The following instructions will aid in ordering parts from the Parts Lists, tables 6-2 through 6-4.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 500-1
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut, 06608

b. Include the following information:

1) Model and Serial Number of instrument.

2) Singer Part Number.

3) Reference Symbol Number.

4) Description (as shown on list).

6-5. HOW TO USE THE PARTS LIST

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described; SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

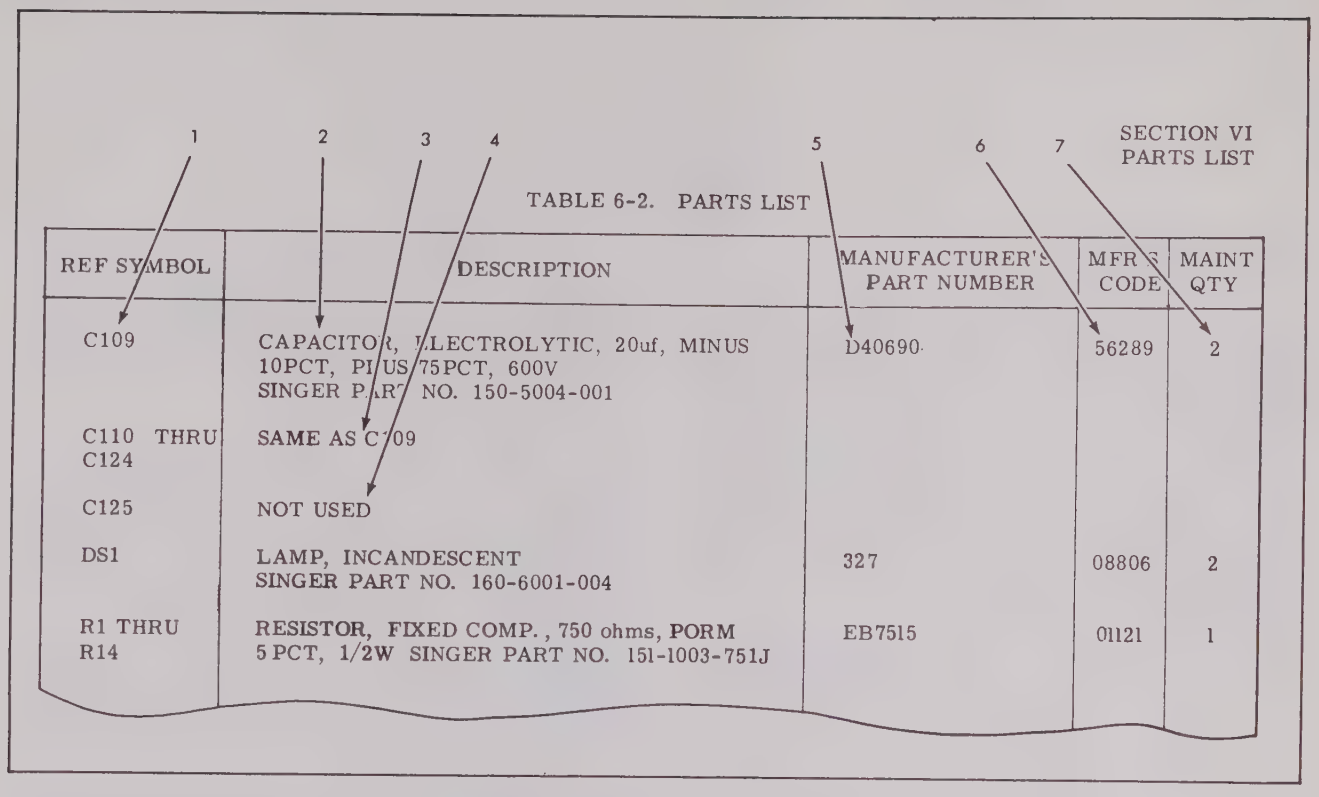


Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name
B	Electronic Inst. & Specialty Co. Winchester, Mass
INSTD	Industry Standard
00656	Aerovox Corp. Bedford, Mass.
01009	Alden Products Co. Brockton, Mass.
01121	Allen-Bradley Co. Milwaukee, Wisc.
02660	Amphenol Corp. Broadview, Ill.
02777	Hopkins Engineering Co. San Fernando, Calif.
03508	General Electric Co. Semiconductor Products Dept. Syracuse, N.Y.
03888	Pyrofilm Resistor Co., Inc. Cedar Knolls, N.J.
04713	Motorola Semiconductor Products, Inc. Phoenix, Ariz.
06751	Components, Inc. Phoenix, Ariz.
07263	Fairchild Semiconductor Division Mountain View, Calif.
07886	National Radio Co., Inc. Melrose, Mass.
11236	CTS of Berne, Inc. Berne, Ind.
12126	Kidco, Inc. Medford, N.J.
12598	RLC Electronics, Inc. Port Chester, N.Y.
14099	Semtech Corp. Newbury Park, Calif.
16068	International Diode Corp. Jersey City, N.J.

TABLE 6-1. MANUFACTURER'S CODE (Cont'd)

Number	Name
16299	Corning Electronics Raleigh, N.C.
16665	The Singer Company Instrumentation Division Bridgeport, Conn.
17545	Atlantic Semiconductors, Inc. Asbury Park, N.J.
18583	Curtis Instruments, Inc. Mt. Kisco, N.Y.
26805	Americon Corp. Waltham, Mass.
27338	Addington Laboratories, Inc. San Lazard, Calif.
56289	Sprague Electric Co. North Adams, Mass.
63743	Ward Leonard Electric Co. Mt. Vernon, N.Y.
70309	Allied Control Co., Inc. New York, N.Y.
70563	Amperite Co. Union City, N.J.
71400	Bussmann Mfg. Division St. Louis, Mo.
71590	Centralab Division Milwaukee, Wisc.
72136	Electro Motive Mfg. Co., Inc. Willimantic, Conn.
72619	Dialight Corp. Brooklyn, N.Y.
72825	Hugh H. Eby, Inc. Philadelphia, Pa.
72982	Erie Technological Products, Inc. Erie, Pa.
73445	Amperex Electronics Corp. Hicksville, L.I., N.Y.
74545	Harvey Hubbell, Inc. Bridgeport, Conn.
74868	Amphenol RF Division Danbury, Conn.
74970	E.F. Johnson Co. Waseca, Minn.
75042	IRC, Inc. Philadelphia, Pa.
75915	Littelfuse Inc. Des Plaines, Ill.
76487	James Millen Mfg. Co., Inc. Malden, Mass.
78488	Stackpole Carbon Co. St. Marys, Pa.
78526	Stanwyck Winding Co., Inc. Newburgh, N.Y.
80031	Mepco, Inc. Morristown, N.J.
81312	Winchester Electronics Division Oakville, Conn.
81483	International Rectifier Corp. El Segundo, Calif.
82389	Switchcraft, Inc. Chicago, Ill.
82768	Phillips Advance Control Co. Joliet, Ill.
82877	Rotron Mfg. Co., Inc. Woodstock, N.Y.
86684	Radio Corporation of America Electronic Components & Devices Harrison, N.J.
88236	Varian-Bomac Division Beverly, Mass.
91293	Johanson Mfg. Corp. Boonton, N.J.
91418	Radio Materials Co. Chicago, Ill.
91662	Elco Corp. Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc. Wakefield, Mass.
91967	National Tel-Tronics Corp. Yonkers, N.Y.

TABLE 6-1. MANUFACTURER'S CODE (Cont'd)

Number	Name
93332	Sylvania Electric Products, Inc. Semiconductor Products Division Woburn, Mass.
93790	Cornell-Dubilier Electronics Division New Bedford, Mass.
95238	Continental Connector Corp. Woodside, N.Y.
95264	Lerco Electronics, Inc. Burbank, Calif.
95275	'Vitramon, Inc. Bridgeport, Conn.
95354	Methode Electronics Inc. Chicago, Ill.
96341	Microwave Associates Burlington, Mass.
98291	Sealectro Corp. Mamaroneck, N.Y.
99120	Plastic Capacitors, Inc. Chicago, Ill.

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
AT1	INPUT ATTENUATOR,0-60 DB IN 10 DB STEPS,DC TO 12.4 GHZ	110-0252-001	16665	1
AT1J1 AND J2	CONNECTOR,COAXIAL,TYPE N,FEMALE NON-REPLACEABLE PARTS OF AT1			
B1	FAN,SKELETON,115V,60HZ SINGER PART NO. 177-0001-001	SKC-2	82877	1
CP1	ADAPTER,COAXIAL,BULKHEAD,TYPE TNC MALE TO TYPE TNC FEMALE SINGER PART NO. 556146-969	10108-1	91737	1
CP1J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF CP1			
CP1J2	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF CP1			
CP2	BIAS T ASSY	135-0083-001	16665	1
CP2C1	CAPACITOR,FEEDTHROUGH NON-REPLACEABLE PART OF CP2			
CP2C2	CAPACITOR NON-REPLACEABLE PART OF CP2			
CP2J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF CP2			
CP2L1	RF CHOKE NON-REPLACEABLE PART OF CP2			
CP2P1	SAME AS CP2J1			
CR1	DIODE,ZENER,SILICON,120V,PORM 5 PCT,1W SINGER PART NO. 556147-218	1N3046B	04713	1
CR2 THRU CR5	BRIDGE RECTIFIER ASSY,SILICON SINGER PART NO. 556146-694	7S50	17545	1
C1 THRU C5	CAPACITOR,FIXED,MICA,3000 PF,PORM 2 PCT,500V SINGER PART NO. 150-2003-302FGO	DM19F302G0500WV4CR	72136	1
C6	CAPACITOR,FIXED,ELECTROLYTIC,7 UF,250V SINGER PART NO. 556147-170	39D705F250EE4	56289	1
C7	CAPACITOR,FIXED,PLASTIC,HIGH VOLTAGE,4 UF, 3KV,W/FOOTED BRACKETS SINGER PART NO. 556147-173	EP30-405	99120	1
C8	CAPACITOR,FIXED,CERAMIC DISC,0.05 UF,1000V SINGER PART NO. 556074-058	BPD-0.05UF/1000V	00656	1
C9	CAPACITOR,FIXED,METALLIZED PAPER,1 UF,PORM 20 PCT,200VDCW SINGER PART NO. 150-3002-1052	P8292ZN13	00656	1
C10	CAPACITOR,FIXED,MICA,250 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-251FJO	DM15F251J0500WV4CR	72136	1
DS1 AND DS2	LIGHT,INDICATOR,NEON,NO RESISTOR,PERM LAMP. WHITE SINGER PART NO. 556147-244	249-7840-0335-504	72619	1
E1	PLATE CAP,CERAMIC SINGER PART NO. 168-8030-001	SPP-3	07886	1
E2	PLATE CAP,W/18-INCH LEAD SINGER PART NO. 556146-161	90TSL	01009	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
F1 AND F2	FUSE,CARTRIDGE,SLOW BLOW,1.6 AMP,250 VOLTS SINGER PART NO. 556006-117	31301.6	75915	20
F3	FUSE,CARTRIDGE,SLOW BLOW,1 AMP,125V SINGER PART NO. 556006-017	313001	75915	5
J1	CONNECTOR,RECEPTACLE,MINIATURE,HV,6 FEMALE CONTACTS SINGER PART NO. 556147-213	PM6SLR	81312	1
J2	CONNECTOR,RECEPTACLE,SUB-MINIATURE,20 SOCKETS,POLARIZED SINGER PART NO. 556146-754	SM20-20PGD	95238	1
J3 THRU J9	CONNECTOR,RECEPTACLE,ELEC.,FEMALE,22 CONTACTS,PC CARD TYPE SINGER PART NO. 168-3002-007	71-6022-1107-00	95354	1
J10	CONNECTOR,RECEPTACLE,ELEC.,3 FEMALE CONTACTS SINGER PART NO. 556010-048	5284	74545	1
J11	CONNECTOR,PLUG,SUB-MINIATURE,11 PINS, POLARIZED SINGER PART NO. 556146-750	SM11-20PGD	95238	1
J12	CONNECTOR,RECEPTACLE,ELEC.,1 PIN,1 CONTACT, SIDE MOUNTING,W/HOOD SINGER PART NO. 556010-240	JFA1P1SH	81312	1
J13	CONNECTOR,RECEPTACLE,ELEC.,5 FEMALE CONTACTS SINGER PART NO. 556010-057	126-218	02660	1
J14	CONNECTOR,COAXIAL,BULKHEAD RECEPTACLE,MINIATURE SNAP-ON TYPE,MALE SINGER PART NO. 556147-018	50-010-0000	98291	1
J15	CONNECTOR,ELEC.,FEMALE,2 TERMINALS SINGER PART NO. 556147-243	455F	91967	1
K1	RELAY,3PDT,115VAC COIL,1600 OHMS,3VA,10A CONTACTS SINGER PART NO. 556147-141	GHH/3C/115VC	82768	1
K2	RELAY,THERMAL,115V HTR,60 SECOND DELAY, NORMALLY-OPEN CONTACTS SINGER PART NO. 556019-081	115N060T	70563	1
K3	RELAY,TELEPHONE,4PDT,24VDC COIL,700 OHMS, 5ADC CONT., PLASTIC ENCLOSED SINGER PART NO. 158-0004-001	TF-154-CC-CC24VDC	70309	1
P2	CONNECTOR,PLUG,MINIATURE,HV,6 MALE CONTACTS SINGER PART NO. 556147-212	PM6PLS	81312	1
P3	CONNECTOR,ELEC.,THREE-PRONG,POLARIZED, W/7 FOOT LINE CORD	556161-213	16665	1
P4	CONNECTOR,RECEPTACLE,SUB-MINIATURE,11 SOCKETS,POLARIZED SINGER PART NO. 556146-751	SM11-20SGD	95238	1
P5 AND P6	CONNECTOR,COAXIAL,TYPE TNC,MALE SINGER PART NO. 556147-020	59-007-0000	98291	1
P7	CONNECTOR,ELEC.,MALE,2 TERMINALS SINGER PART NO. 556147-242	455M	91967	1
Q1 AND Q2	TRANSISTOR,GERMANIUM,PNP SINGER PART NO. 556146-678	2N3613	INSTD	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R1 AND R2	RESISTOR,FIXED,WIREWOUND,100 OHMS,PORM 5 PCT,5W SINGER PART NO. 151-2002-101J	5XM100	63743	1
R5	POTENTIOMETER,PRECISION,300K OHMS,PORM .25 PCT,LINEAR,5W,10T	151-0028-304	16665	1
R6	RESISTOR,FIXED,COMP.,12K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-123J	CB1235	01121	1
R7	RESISTOR,FIXED,COMP.,24K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-243J	CB2435	01121	1
R8 THRU R15	RESISTOR,FIXED,COMP.,390K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-394J	HB3945	01121	2
R16 THRU R20	RESISTOR,FIXED,TIN OXIDE,91K OHMS,PORM 2 PCT,2W SINGER PART NO. 151-2011-002	C-42S/91KPORM2PCT	16299	1
R21	RESISTOR,FIXED,COMP.,200 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-201J	GB2015	01121	1
R22 THRU R24	RESISTOR,FIXED,METAL FILM,90K OHMS,PORM 5 PCT,7W SINGER PART NO. 151-2015-903	LP1-7/90K PORM5PCT	16299	1
R25 THRU R29	RESISTOR,FIXED,COMP.,330K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-334J	HB3345	01121	1
R30	RESISTOR,FIXED,COMP.,3.6K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-362J	HB3625	01121	1
R31	RESISTOR,FIXED,COMP.,47K OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-473J	GB4735	01121	1
R32	RESISTOR,FIXED,COMP.,51K OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-513J	GB5135	01121	1
R33	RESISTOR,FIXED,COMP.,100 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-101J	GB1015	01121	1
R34	RESISTOR,FIXED,COMP.,150K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-154J	HB1545	01121	1
R35 AND R36	RESISTOR,FIXED,COMP.,1K OHM,PORM 5 PCT,1/2W SINGER PART NO. 151-1003-102J	EB1025	01121	1
R37	RESISTOR,FIXED,COMP.,33 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-330J	GB3305	01121	1
R38	RESISTOR,VARIABLE,25K OHMS,PORM 30 PCT,1/2W NON-REPLACEABLE PART OF S9			
R39	RESISTOR,FIXED,METAL FILM,9.76K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-9761	PME60/T-0/9760/PORM1	03888	1
R40	RESISTOR,FIXED,METAL FILM,3.65K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-3651	PME60/T-0/3650/PORM1	03888	1
R41	RESISTOR,FIXED,METAL FILM,1.020K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-1021	PME60/T-0/1020/PORM1	03888	1
R42	RESISTOR,FIXED,METAL FILM,340 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-3400	PME60/T-0/340/PORM1P	03888	1
R43	RESISTOR,FIXED,METAL FILM,100 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-1000	PME60/T-0/100/PORM1P	03888	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R44	RESISTOR,FIXED,METAL FILM,49.9 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-49R9	PME60/T-0/49.9/PORM1	03888	1
R45	RESISTOR,FIXED,METAL FILM,9.09K OHMS,PORM1 PCT,1/4W SINGER PART NO. 151-2014-9091	PME60/T-0/9090/PORM1	03888	1
R46	RESISTOR,FIXED,METAL FILM,30.1K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-3012	PME60/T-0/30100/PORM	03888	1
R47	RESISTOR,FIXED,METAL FILM,100K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-1003	PME60/T-0/100K/PORM1	03888	1
R48	RESISTOR,FIXED,METAL FILM,301K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-3013	PME60/T-0/301K/PORM1	03888	1
R49.	RESISTOR,FIXED,METAL FILM,1 MEGOHM,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-1004	PME60/T-0/1MEG/PORM1	03888	1
R50	RESISTOR,FIXED,METAL FILM,3.01 MEGOHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-3014	PME60/T-0/3.01MEG/PO	03888	1
R51	RESISTOR,FIXED,DEP. CARBON,150 OHMS,PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1500F	C1/8E150PORM1PCT	12126	1
R52	RESISTOR,FIXED,DEP. CARBON,1.82K OHMS,PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1821F	C1/8E1820PORM1PCT	12126	1
R53	RESISTOR,FIXED,DEP. CARBON,499 OHMS,PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B4990F	C1/8E499PORM1PCT	12126	1
R54	RESISTOR,VARIABLE,20K OHMS,PORM 30 PCT,1/2W NON-REPLACEABLE PART OF S9			
R55	RESISTOR,FIXED,METAL FILM,2.49K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-2491	PME60/T-0/2490/PORM1	03888	1
R56	RESISTOR,FIXED,METAL FILM,845 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-8450	PME60/T-0/845/PORM1P	03888	1
R57	RESISTOR,FIXED,METAL FILM,412 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-4120	PME60/T-0/412/PORM1P	03888	1
R58	RESISTOR,FIXED,METAL FILM,249 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-2490	PME60/T-0/249/PORM1P	03888	1
R59	RESISTOR,FIXED,METAL FILM,165 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-1650	PME60/T-0/165/PORM1P	03888	1
R60	RESISTOR,FIXED,METAL FILM,118 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-1180	PME60/T-0/118/PORM1P	03888	1
R61	RESISTOR,FIXED,METAL FILM,715 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014 -7150	PME60/T-0/715/PORM1P	03888	1
R62	RESISTOR,FIXED,COMP.,150 OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-151J	HB1515	01121	1
R63	RESISTOR,VARIABLE,COMP.,LINEAR,5K OHMS,PORM 10 PCT,1/2W SINGER PART NO. 151-0001-014	6634	01121	1
R65 AND R66	RESISTOR,FIXED,COMP.,200K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-204J	CB2045	01121	1
R67	SAME AS R7			
S1 THRU S5	SWITCH,PUSHBUTTON NON-REPLACEABLE PARTS OF A16			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
S6 THRU S8	SWITCH,PUSHBUTTON NON-REPLACEABLE PARTS OF A15			
S9	SWITCH,ROTARY,4 POLE,6 POSITION,W/R38,R54 AND S12	133-0096-001	16665	1
S10	SWITCH,ROTARY,4 POLE,9 POSITION	133-0095-001	16665	1
S11	SWITCH,SLIDE,DPDT,SLOTTED KNOB SINGER PART NO. 556146-590	46206LF	82389	1
S12	SWITCH,ROTARY,SPST NON-REPLACEABLE PART OF S9			
TP1	JACK,TIP,VIOL SINGER PART NO. 556146-914	105-612	74970	1
TP2	JACK,TIP,YELLOW SINGER PART NO. 556010-214	105-607	74970	1
TP3	JACK,TIP,BLACK SINGER PART NO. 556146-913	105-603	74970	1
TP4	JACK,TIP,RED SINGER PART NO. 556146-912	105-602	74970	1
TP5	JACK,TIP,ORANGE SINGER PART NO. 556010-224	105-606	74970	1
TP6	SAME AS TP4			
T1	TRANSFORMER,POWER	132-0209-001	16665	1
T2	TRANSFORMER,POWER	132-0208-001	16665	1
T3	TRANSFORMER,POWER	132-0326-001	16665	1
V1	ELECTRON TUBE,BEAM PENTODE SINGER PART NO. 556147-163	8068	INSTD	1
V2	ELECTRON TUBE,BEAM PENTODE SINGER PART NO. 556147-164	7239	INSTD	1
V3	ELECTRON TUBE,BACKWARD WAVE OSCILLATOR,4.0 TO 8.08 GHZ	134-0032-001	16665	1
W1	CABLE ASSY	102-9200-470	16665	1
W1P1	CONNECTOR,COAXIAL,PLUG,TYPE N,MALE SINGER PART NO. 168-4002-002	UG-536B/U ANTI-TARN	INSTD	1
W1P2	CONNECTOR,COAXIAL,PLUG,TYPE TNC,MALE SINGER PART NO. 168-4038-001	6001/ANTI-TARN	91737	7
W2	CABLE ASSY	102-9200-471	16665	1
W2P1	SAME AS W1P1			
W2P2	SAME AS W1P2			
W3	CABLE ASSY	103-1848-001	16665	1
W3P1 AND P2	CONNECTOR,COAXIAL,PLUG,TYPE N,MALE SINGER PART NO. 168-4060-001	3001-7941	26805	1
W4	CABLE ASSY	102-9111-01^	16665	1
W4P1 AND P2	CONNECTOR,COAXIAL,PLUG,MINIATURE SNAP-ON TYPE,FEMALE SINGER PART NO. 168-4031-001	51-007-0000	98291	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
W5	CABLE ASSY	102-9112-015	16665	1
W5P1 AND P2	SAME AS W1P2			
W6	CABLE ASSY	102-9111-015	16665	1
W6P1 AND P2	SAME AS W4P1			
XF1 AND XF2	FUSEHOLDER,EXTRACTOR POST SINGER PART NO. 556006-072	341001	75915	1
XF3	FUSEHOLDER SINGER PART NO. 556006-003	4405	71400	1
XK1	SOCKET,TUBE,11 CONTACTS SINGER PART NO. 556024-066	77-M1P11	02660	1
XK2	SOCKET,TUBE,9 CONTACTS SINGER PART NO. 556024-019	TS103P01	91662	1
XK3	SOCKET,RELAY SINGER PART NO. 556147-140	30055-2	70309	1
XQ1 AND XQ2	SOCKET,TRANSISTOR SINGER PART NO. 556147-158	9866-15-2	72825	1
XV1	SOCKET,TUBE,OCTAL SINGER PART NO. 556024-041	9076	72825	1
XV2	SOCKET,ELECTRON TUBE,9 PIN,MINIATURE SINGER PART NO. 167-0002-001	05-0903-07	91662	1
A1	RF/IF SHELF ASSY	103-1645-001	16665	1
A1AT1	50 OHM TERMINATION ASSY	135-0079-001	16665	1
A1AT1P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1AT1			
A1AT2 THRU AT4	ATTENUATOR,3 DB,PORM 1 DB,DC TO 11 GHZ	134-0022-005	16665	1
A1AT2J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1AT2			
A1AT2P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1AT2			
A1AT3J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART PF A1AT3			
A1AT3P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1AT3			
A1AT4J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1AT4			
A1AT4P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1AT4			
A1AT5	ATTENUATOR,6 DB,PORM 1.25 DB,DC TO 11 GHZ	134-0022-001	16665	1
A1AT5J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1AT5			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1AT5P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1AT5			
A1AT6	ATTENUATOR,20 DB,PORM 1.5 DB,DC TO 11 GHZ	134-0022-003	16665	1
A1AT6J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACE PART OF A1AT6			
A1AT6P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1AT6			
A1CP1	FREQUENCY SELECTIVE T ASSY	134-0054-001	16665	1
A1CP1C1	CAPACITOR,BYPASS NON-RPLACEABLE PART OF A1CP1			
A1CP1J1 THRU J3	CONNECTOR,COAXIAL,TYPE TNC,FEMALE			
A1CP1L1	RF CHOKE NON-REPLACEABLE PART OF A1CP1			
A1CP2	ADAPTER,COAXIAL,STRAIGHT,TYPE TNC,MALE TO MALE SINGER PART NO. 168-4056-001	6020/ANTI-TARN	91737	1
A1CP2J1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1CP2			
A1CP2P1	SAME AS A1CP2J1			
A1CP3	ADAPTER,T,COAXIAL,TYPE TNC SINGER PART NO. 168-4055-001	6012/ANTI-TARN	91737	1
A1CP3J1 AND J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1CP3			
A1CP3P1	SAME AS A1CP3J1			
A1CP4	ADAPTER,COAXIAL,STRAIGHT,TYPE N MALE TO TYPE TNC MALE SINGER PART NO. 168-4057-001	6044/ANTI-TARN	91737	1
A1CP4J1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1CP4			
A1CP4P1	CONNECTOR,COAXIAL,TYPE N,MALE NON-REPLACEABLE PART OF A1CP4			
A1CP5	SAME AS A1CP3			
A1CP5J1 AND J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1CP5			
A1CP5P1	SAME AS A1CP5J1			
A1CR1 THRU CR5	DIODE,SILICON SINGER PART NO. 556118-176	1N4002	INSTD	2
A1C1	CAPACITOR,FIXED,TANTALUM,2.2 UF,35V SINGER PART NO. 556146-506	CS13BF225K	06751	1
A1C2	CAPACITOR,FIXED,ELECTROLYTIC,200 UF,PLUS 75 MINUS 10 PCT,15VDC SINGER PART NO. 150-5001-201DS	TE-1164	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1FL1	8 GHZ LOW-PASS FILTER ASSY	103-1809-001	16665	1
A1FL1J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1FL1			
A1FL1P1	CONNECTOR,COAXIAL,TYPE,TNC,MALE NON-REPLACEABLE PART OF A1FL1			
A1FL2	4 GHZ NOTCH FILTER ASSY	103-1790-001	16665	1
A1FL2J1 AND J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1FL2			
A1FL3	5 GHZ LOW-PASS FILTER ASSY	103-1806-001	16665	1
A1FL3J1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1FL3			
A1FL3P1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1FL3			
A1FL4	4 GHZ PRESELECTOR ASSY	103-1700-001	16665	1
A1FL4J1	CONNECTOR AND PROBE ASSY NON-REPLACEABLE PART OF A1FL4			
A1FL4P1	CONNECTOR AND PROBE ASSY NON-REPLACEABLE PART OF A1FL4			
A1FL5	3.84 GHZ PRESELECTOR ASSY	103-1785-001	16665	1
A1FL5J1	CONNECTOR AND PROBE ASSY NON-REPLACEABLE PART OF A1FL5			
A1FL5J2	CONNECTOR AND PROBE ASSY NON-REPLACEABLE PART OF A1FL5			
A1FL6	2 GHZ LOW-PASS FILTER ASSY	132-0384-001	16665	1
A1FL6J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1FL6			
A1FL6P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1FL6			
A1FL7	2.08 GHZ PRESELECTOR ASSY	103-1784-001	16665	1
A1FL7J1 AND J2	CONNECTOR AND PROBE ASSY NON-REPLACEABLE PARTS OF A1FL7			
A1HY1	CIRCULATOR,4 TO 8GHZ SINGER PART NO. 556147-209	117-0600	27338	1
A1HY1J1 THRU J3	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1HY1			
A1J1	CONNECTOR,PLUG,SUB-MINIATURE,14 PINS, POLARIZED SINGER PART NO. 556146-752	SM14-20PGD	95238	1
A1K1	RELAY,COAXIAL,SPDT,50 OHM,N SERIES,DC TO 12.4 GHZ,50W,28VDC COIL SINGER PART NO. 158-0003-001	SR-2-N-D	12598	1
A1K1J1 THRU J3	CONNECTOR,COAXIAL,TYPE N,FEMALE NON-REPLACEABLE PARTS OF A1K1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1K2 THRU K5	RELAY,COAXIAL,SPDT,SHORTING,26VDC COIL,DC TO 8GHZ SINGER PART NO. 556147-177	360-11892-1001	74868	1
A1K2J1 THRU J3	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1K2			
A1K3J1 THRU J3	CONNECTOR,COAXIAL,TYPE,TNC,FEMALE NON-REPLACEABLE PARTS OF A1K3			
A1K4J1 THRU J3	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1K4			
A1K5J1 THRU J3	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1K5			
A1R1	RESISTOR,FIXED,METAL FILM,215 OHMS,PORM 1 PCT,1/8W SINGER PART NO. 151-2013-001	FE12/215/1PCT/C2	80031	1
A1W1	CABLE ASSY	103-1849-001	16665	1
A1W1P1	SAME AS W3P1			
A1W1P2	CONNECTOR,COAXIAL,PLUG,TYPE TNC,MALE SINGER PART NO. 168-4059-001	3101-7941	26805	1
A1W2	CABLE ASSY	102-9112-002	16665	1
A1W2P1 AND P2	SAME AS W1P2			
A1W3	SAME AS W5			
A1W3P1 AND P2	SAME AS W1P2			
A1W4	CABLE ASSY	102-9112-014	16665	1
A1W4P1 AND P2	SAME AS W1P2			
A1W5	CABLE ASSY	102-9112-006	16665	1
A1W5P1 AND P2	SAME AS W1P2			
A1W6	CABLE ASSY	556161-482	16665	1
A1W6P1 AND P2	SAME AS P5			
A1W7	CABLE ASSY	102-9112-009	16665	1
A1W7P1 AND P2	SAME AS W1P2			
A1W8	SAME AS A1W2			
A1W8P1 AND P2	SAME AS W1P2			
A1W9	CABLE ASSY	103-1811-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1W9P1 AND P2	CONNECTOR,COAXIAL,TYPE TNC MALE NON-REPLACEABLE PARTS OF A1W9			
A1W10	CABLE ASSY	102-9112-008	16665	1
A1W10P1 AND P2	SAME AS W1P2			
A1W11	CABLE ASSY	102-9112-013	16665	1
A1W11P1 AND P2	SAME AS W1P2			
A1W12	CABLE ASSY	102-9112-012	16665	1
A1W12P1 AND P2	SAME AS W1P2			
A1W13	CABLE ASSY	102-9112-010	16665	1
A1W13P1 AND P2	SAME AS W1P2			
A1W14	SAME AS A1W12			
A1W14P1 AND P2	SAME AS W1P2			
A1W15	CABLE ASSY	102-9112-306	16665	1
A1W15P1	SAME AS W1P2			
A1W15P2	CONNECTOR,COAXIAL,PLUG,RIGHT ANGLE,TYPE TNC, MALE SINGER PART NO. 556146-974	6039/ANTI-TARN	91737	1
A1W16	SAME AS A1W12			
A1W16P1 AND P2	SAME AS W1P2			
A1A1	SECOND MIXER/160 MHZ PREAMPLIFIER ASSY	103-1675-001	16665	1
A1A1CR1	DIODE NON-REPLACEABLE PART OF A1A1J1			
A1A1CR2	DIODE NON-REPLACEABLE PART OF A1A1J2			
A1A1C1 THRU C3	CAPACITOR,FIXED,CERAMIC DISC,470 PF,PORM 10 PCT,1000VDCW SINGER PART NO. 556146-695	DD-471	71590	2
A1A1C4	CAPACITOR,VARIABLE,CERAMIC,MINIATURE,2-8 PF SINGER PART NO. 150-0008-001	538-011A2-8	72982	1
A1A1C5	SAME AS A1A1C1			
A1A1C6	CAPACITOR,FIXED,ELECTROLYTIC,10 UF,PLUS 75 MINUS 10 PCT,25VDC SINGER PART NO. 150-5001-100ES	TE-1204	56289	1
A1A1FL1 THRU FL4	FILTER,FEEDTHRU,5000 PF,200WVDC,10A MAX. SINGER PART NO. 556146-774	1270-016/NUT&LKWSHR	72982	3
A1A1J1 AND J2	CONNECTOR AND MIXER ASSY	103-1761-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1A1J3	CONNECTOR,COAXIAL,PANEL RECEPTACLE,RIGHT ANGLE,TYPE TNC,FEMALE SINGER PART NO. 556146-968	6022	91737	1
A1A1K1	RELAY,REED,MINIATURE,SPDT,12VDC,13K OHM COIL SINGER PART NO. 158-0002-001	274	B	1
A1A1L1	INDUCTOR,FIXED	132-0360-001	16665	1
A1A1L2	INDUCTOR,FIXED	132-0360-002	16665	1
A1A1Q1	TRANSISTOR,SILICON,NPN SINGER PART NO. 153-0004-001	SE5020	07263	1
A1A1R1	RESISTOR,FIXED,COMP.,1K OHM,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	6
A1A1R2	RESISTOR,FIXED,COMP.,10K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-103J	CB1035	01121	5
A1A1R3	RESISTOR,FIXED,COMP.,2K OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-202J	CB2025	01121	1
A1A1R4	RESISTOR,FIXED,COMP., 620 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-621J	CB6215	01121	1
A1A1R5	RESISTOR,FIXED,COMP.,430 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-431J	CB4315	01121	1
A1A1R6	RESISTOR,FIXED,COMP.,12 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-120J	CB1205	01121	1
A1A1R7	SAME AS A1A1R5			
A1A1T1	TRANSFORMER,RF,TUNABLE	132-0358-001	16665	1
A1A2	160 MHZ BAND-PASS FILTER/AMPLIFIER ASSY	103-1676-001	16665	1
A1A2C1	CAPACITOR,FIXED,COMP.,3.0 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-3R0J	GA3.0PFPORM5PCT	78488	1
A1A2C2	CAPACITOR,VARIABLE,CERAMIC,5.5-18 PF,350VDCW SINGER PART NO. 150-0009-002	538-002A5.5-18	72982	1
A1A2C4	CAPACITOR,FIXED,COMP.,0.82 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-R82J	GA0.82PFPORM5PCT	78488	1
A1A2C5	SAME AS A1A2C2			
A1A2C6	CAPACITOR,FIXED,PORCELAIN,10PF,PORM 5 PCT, 500VDCW SINGER PART NO. 150-1008-001	VY10CA100JA	95275	1
A1A2C7	CAPACITOR,FIXED,COMP.,1.0 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-1R0J	GA1PFPORM5PCT	78488	1
A1A2C8	SAME AS A1A2C2			
A1A2C10	CAPACITOR,FIXED,COMP.,8.2 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-8R2J	GA8.2PFPORM5PCT	78488	1
A1A2C11	SAME AS A1A1C1			
A1A2C12	SAME AS A1A1C4			
A1A2C13	SAME AS A1A1C1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1A2FL1	SAME AS A1A1FL1			
A1A2J1	SAME AS A1A1J3			
A1A2J2	CONNECTOR,COAXIAL,PANEL RECEPTACLE,TYPE TNC, FEMALE SINGER PART NO. 556146-629	6014/ANTI-TARN	91737	1
A1A2L1 THRU L3	INDUCTOR,FIXED	132-0357-001	16665	1
A1A2Q1	SAME AS A1A1Q1			
A1A2R1	SAME AS A1A1R2			
A1A2R2	SAME AS A1A1R3			
A1A2R3	SAME AS A1A1R5			
A1A2R4	SAME AS A1A1R6			
A1A2R5	SAME AS A1A1R5			
A1A2R6	SAME AS A1A1R4			
A1A2T1	SAME AS A1A1T1			
A1A3	1.92 GHZ OSCILLATOR ASSY	103-1805-001	16665	1
A1A3C1	CAPACITOR,VARIABLE,MINIATURE,0.8-10 PF,250V SINGER PART NO. 150-0011-001	JMC2954	91293	1
A1A3FL1 AND FL2	SAME AS A1A1FL1			
A1A3J1	CONNECTOR,COAXIAL,BULKHEAD RECEPTACLE,TYPE TNC,FEMALE	149-0200-001	16665	1
A1A3P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1A3			
A1A3Q1	TRANSISTOR,SILICON,NPN SINGER PART NO. 153-0002-001	MT1060A	07263	1
A1A3R1	RESISTOR,FIXED,COMP.,2.7 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-2R7J	CB2R75	01121	1
A1A3R2	SAME AS A1R1			
A1A4	RADIAL LINE MIXER ASSY	103-1636-001	16665	1
A1A4CP1	CRYSTAL HOLDER ASSY	123-0174-001	16665	1
A1A4CR1	DIODE ASSY	103-1965-001	16665	1
A1A4J1 AND J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A1A4			
A1A4J3	CONNECTOR AND PROBE ASSY NON-REPLACEABLE PART OF A1A4			
A1A5	FREQUENCY DOUBLER ASSY	103-1644-001	16665	1
A1A5J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1A5			
A1A5P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1A5			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1A6	T MIXER ASSY	103-1815-001	16665	1
A1A6AT1	SAME AS A1AT2	103-1815-001	16665	1
A1A6AT1J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1A6AT1			
A1A6AT1P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A1A6AT1			
A1A6CP1	MIXER ASSY	134-0019-001	16665	1
A1A6CP1J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1A6CP1			
A1A6CP1P1	SAME AS A1A6CP1J1			
A1A6CP2	CRYSTAL HOLDER ASSY	103-1814-001	16665	1
A1A6CP2J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A1A6CP1			
A1A6CR1	DIODE,SILICON SINGER PART NO. 154-0007-001	1N415C	96341	1
A2	PHASE LOCK CASTING ASSY	103-1708-001	16665	1
A2FL1 THRU FL4	SAME AS A1A1FL1			
A2FL5	TERMINAL,FEEDTHRU SINGER PART NO. 556009-461	6080	95264	1
A2FL6	SAME AS A1A1FL1			
A2J1	CONNECTOR,COAXIAL,BULKHEAD RECEPTACLE,MINI-ATURE SCREW-ON TYPE,MALE SINGER PART NO. 168-4034-001	51-010-0000	98291	1
A2P1	CONNECTOR,PLUG,3 TERMINALS	128-1036-007	16665	1
A2P2	CONNECTOR,PLUG,2 TERMINALS	128-1036-010	16665	1
A2P3	CONNECTOR,PLUG,4 TERMINALS	128-1036-005	16665	1
A2P4	CONNECTOR,COAXIAL,RIGHT ANGLE PLUG,MINIATURE SNAP-ON TYPE,FEMALE SINGER PART NO. 556205-007	51-011-0000	98291	1
A2R1	RESISTOR,FIXED,COMP.,3K OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-302J	CB3025	01121	1
A2W1	CABLE ASSY	102-9200-390	16665	1
A2W1P1 AND P2	SAME AS A2P4			
A2W2	CABLE ASSY	102-9200-391	16665	1
A2W2P1 AND P2	SAME AS A2P4			
A2A1	21 MHZ AMPLIFIER/LIMITER ASSY	103-1660-001	16665	1
A2A1CR1 AND CR2	DIODE,HOT CARRIER SINGER PART NO. 154-0004-001	FH1100	07263	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A1C1	CAPACITOR,VARIABLE,CERAMIC,MINIATURE,9-35 PF SINGER PART NO. 150-0008-008	538-011D9-35	72982	1
A2A1C2 AND C3	CAPACITOR,FIXED,CERAMIC,0.47 UF,PORM 20 PCT, 25VDC SINGER PART NO. 556120-160	5C11	56289	2
A2A1C4	CAPACITOR,FIXED,CERAMIC DISC,0.022 UF,PLUS 80 MINUS 20 PCT,25V,MINIATURE SINGER PART NO. 556060-105	C069B250G223Z	56289	2
A2A1C5	SAME AS A2A1C2			
A2A1C6	CAPACITOR,FIXED,CERAMIC DISC,0.01 UF,PLUS 60 MINUS 40 PCT,250V SINGER PART NO. 556060-146	DA140-172B	71590	2
A2A1C7	CAPACITOR,FIXED,MICA,43 PF,PORM 2 PCT.,500V SINGER PART NO. 150-2002-430EGO	DM15E430G0500WV4CR	72136	1
A2A1C8	CAPACITOR,FIXED,MICA,150 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-151FGO	DM15F151G0500WV4CR	72136	1
A2A1C9 AND C10	SAME AS A2A1C2			
A2A1C11	SAME AS A2A1C4			
A2A1C12	SAME AS A2A1C2			
A2A1C13	CAPACITOR,FIXED,MICA,68 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-680EGO	DM15E680G0500WV4CR	72136	1
A2A1J1 AND J2	CONNECTOR,COAXIAL,RECEPTACLE,MINIATURE SNAP-ON TYPE,MALE SINGER PART NO. 556205-001	51-051-0000	98291	1
A2A1L1	CHOKE,RF,2.2 UH SINGER PART NO. 556012-173	70F223A1	76487	1
A2A1L2	INDUCTOR,VARIABLE	132-0291-001	16665	1
A2A1L3	INDUCTOR,VARIABLE	132-0290-001	16665	1
A2A1Q1 AND Q2	TRANSISTOR,SILICON,NPN SINGER PART NO. 153-0007-001	A467	73445	1
A2A1R1	SAME AS A1A1R1			
A2A1R2	RESISTOR,FIXED,COMP.,100 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-101J	CB1015	01121	3
A2A1R3	RESISTOR,FIXED,COMP.,8.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-822J	CB8225	01121	1
A2A1R4	SAME AS A1A1R1			
A2A1R5	RESISTOR,FIXED,COMP.,10 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-100J	CB1005	01121	1
A2A1R6 AND R7	SAME AS A2A1R2			
A2A1R8	SAME AS A1A1R2			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A1R9	SAME AS A2A1R2			
A2A1R10	SAME AS A2A1R3			
A2A1R11	SAME AS A1A1R1			
A2A1R12	RESISTOR,FIXED,COMP.,30 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-300J	CB3005	01121	1
A2A2	21 MHZ REFERENCE OSCILLATOR ASSY	103-1658-001	16665	1
A2A2C1	CAPACITOR,FIXED,COMP.,0.22 PF,PORM 10 PCT, 500V SINGER PART NO. 150-4001-R22K	GA0.22PFPORM10PCT	78488	1
A2A2C2	CAPACITOR,FIXED,MICA,180 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-181FGO	DM15F181G0500WV4CR	72136	1
A2A2C3	CAPACITOR,FIXED,CERAMIC,1000 PF,PORM 10 PCT, 1000VDCW SINGER PART NO. 556060-046	DD-102	71590	3
A2A2C4	CAPACITOR,FIXED,MICA,10 PF,PORM 5 PCT,500VDC SINGER PART NO. 150-2002-100CJO	DM15C100J0500WV4CR	72136	1
A2A2C5	CAPACITOR,VARIABLE,CERAMIC,MINIATURE,5.5 TO 18 PF,PC BD MTG SINGER PART NO. 150-0008-002	538-011A5.5-18	72982	1
A2A2C6 THRU C8	SAME AS A2A2C3			
A2A2C9	SAME AS A2A2C5			
A2A2C10	SAME AS A2A2C3			
A2A2C11	SAME AS A2A2C4			
A2A2C12	SAME AS A2A2C3			
A2A2J1	SAME AS A2A1J1			
A2A2L1	INDUCTOR,FIXED,10 UH,PORM 10 PCT SINGER PART NO. 556200-008	DINK-10	78526	1
A2A2Q1 AND Q2	TRANSISTOR,SILICON,NPN SINGER PART NO. 556146-256	2N3646	INSTD	1
A2A2R1	RESISTOR,FIXED,COMP.,1.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-122J	CB1225	01121	1
A2A2R2	SAME AS A1A1R1			
A2A2R3	RESISTOR,FIXED,COMP.,240 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-241J	CB2415	01121	1
A2A2R4	SAME AS A2A1R2			
A2A2R5	RESISTOR,FIXED,COMP.,3K OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-302J	CB3025	01121	1
A2A2R6	SAME AS A2A1R2			
A2A2R7	RESISTOR,FIXED,COMP.,4.7K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-472J	CB4725	01121	1
A2A2R8	SAME AS A2A1R2			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A2T1	TRANSFORMER,RF,TUNABLE	132-0293-001	16665	1
A2A2T2	TRANSFORMER,RF,TUNABLE	132-0292-001	16665	1
A2A2Y1	CRYSTAL,QUARTZ,IN HC-18/U HOLDER,SOLDER-IN TYPE SINGER PART NO. 556147-162	CR-55/U 21.00MHZ	INSTD	1
A2A3	PHASE DETECTOR ASSY	103-1659-001	16665	1
A2A3BR1 AND BR2	DIODE QUAD SINGER PART NO. 154-0005-001	Q4-600	16068	1
A2A3C1 THRU C3	SAME AS A2A1C4			
A2A3C4	CAPACITOR,FIXED,MICA,75 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-750EGO	DM15E750G0500WV4CR	72136	1
A2A3C5	CAPACITOR,FIXED,MICA,330 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-331FGO	DM15F331G0500WV4CR	72136	1
A2A3C6	CAPACITOR,FIXED,MICA,51 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-510EGO	DM15E510G0500WV4CR	72136	1
A2A3J1 AND J2	SAME AS A2A1J1			
A2A3L1	INDUCTOR,VARIABLE	132-0288-001	16665	1
A2A3Q1	SAME AS A2A1Q1			
A2A3R1	SAME AS A2A2R5			
A2A3R2	SAME AS A1A1R2			
A2A3R3	RESISTOR,FIXED,COMP.,5.1K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-512J	CB5125	01121	2
A2A3R4	SAME AS A1A1R1			
A2A3R5	RESISTOR,FIXED,COMP.,270 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-271J	CB2715	01121	1
A2A3R6	SAME AS A1A1R3			
A2A3R7 AND R8	RESISTOR,FIXED,COMP.,51 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-510J	CB5105	01121	1
A2A3R9	RESISTOR,FIXED,COMP.,220 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-221J	CB2215	01121	1
A2A3T1 THRU T4	TRANSFORMER,RF NON-REPLACEABLE PARTS OF A2A3			
A3	12 VOLT RECTIFIER ASSY	103-1652-001	16665	1
A3CR1 THRU CR8	DIODE,SILICON SINGER PART NO. 556146-689	1N4089	INSTD	3
A3C1 THRU C4	CAPACITOR,FIXED,ELECTROLYTIC,2400 UF,30VDCW SINGER PART NO. 556201-103	39D248G030JP4	56289	1
A3F1 AND F2	FUSE,SLOW BLOW,1-1/4 AMP.,250 VOLTS SINGER PART NO. 556146-743	MDX-1-1/4	71400	20

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3R1 AND R2	RESISTOR,FIXED,COMP.,15K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-153J	CB1535	01121	2
A4	12 VOLT CONTROL ASSY	103-1653-001	16665	1
A4CR1 AND CR2	DIODE,ZENER,SILICON,6.2V,PORM 5 PCT,1/4W SINGER PART NO. 556146-188	1N821	INSTD	1
A4C1	SAME AS A2A2C3			
A4C2	CAPACITOR,FIXED,ELECTROLYTIC,1 UF,PLUS 75 MINUS 10 PCT,25VDC SINGER PART NO. 150-5001-1R0ES	TE-1200	56289	1
A4C3 AND C4	CAPACITOR,FIXED,ELECTROLYTIC,200 UF,25VDCW SINGER PART NO. 556201-101	39D207G025EJ4	56289	1
A4C5	SAME AS A2A2C3			
A4C6	SAME AS A4C2			
A4C7 AND C8	SAME AS A4C3			
A4Q1 AND Q2	TRANSISTOR,SILICON,PNP SINGER PART NO. 556146-255	2N3638	07263	2
A4Q3 AND Q4	TRANSISTOR,SILICON,NPN SINGER PART NO. 556146-677	2N3694	INSTD	1
A4Q5 AND Q6	SAME AS A4Q1			
A4Q7 AND Q8	SAME AS A4Q3			
A4R1	RESISTOR,FIXED,COMP.,560 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-561J	GB5615	01121	1
A4R2	SAME AS A1A1R1			
A4R3	SAME AS A2A2R1			
A4R4	SAME AS A2A1R2			
A4R5	SAME AS A1A1R1			
A4R6	SAME AS A2A1R2			
A4R7	RESISTOR,FIXED,COMP.,2.4K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-242J	CB2425	01121	1
A4R8	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP SINGER PART NO. 556203-010	XHT201-2/500,20PCT	11236	1
A4R9	RESISTOR,FIXED,COMP.,2.7K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-272J	CB2725	01121	1
A4R10	RESISTOR,FIXED,WIREWOUND,MOLDED,0.33 OHM, PORM 10 PCT,2W SINGER PART NO. 556146-922	BWH-0.33,10 PCT	75042	1
A4R11	SAME AS A4R1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A4R12	SAME AS A2A2R1			
A4R13	SAME AS A2A1R2			
A4R14	SAME AS A1A1R1			
A4R15	SAME AS A2A1R2			
A4R16	SAME AS A4R7			
A4R17	SAME AS A4R8			
A4R18	SAME AS A4R9			
A4R19	SAME AS A1A1R1			
A4R20	SAME AS A4R10			
A5	-6.3 VOLT BWO FILAMENT POWER SUPPLY ASSY	103-1654-001	16665	1
A5CR1 THRU CR4	SAME AS A3CR1			
A5CR5	DIODE,SILICON SINGER PART NO. 556147-161	SCE2	14099	1
A5CR6	DIODE,ZENER,SILICON,4.3V,PORM 5 PCT,0.4W SINGER PART NO. 556118-105	1N749	81483	1
A5C1	CAPACITOR,FIXED,ELECTROLYTIC,8000 UF,15VDCW SINGER PART NO. 556201-100	39D808G015JT4	56289	1
A5C2	SAME AS A2A2C3			
A5F1	FUSE,CARTRIDGE,SLOW BLOW,2 AMP,125V,TYPE 3AG SINGER PART NO. 556006-021	313002	75915	5
A5Q1	SINGER PART NO. 556147-165	2N3055	INSTD	1
A5Q2	SAME AS A2A2Q1			
A5Q3 AND Q4	TRANSISTOR,SILICON,NPN SINGER PART NO. 556146-401	2N3638A	INSTD	2
A5R1	RESISTOR,FIXED,COMP.,15K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-153J	EB1535	01121	1
A5R2	RESISTOR,FIXED,COMP.,2K OHMS,PORM 5 PCT,1/2W SINGER PART NO. 151-1003-202J	EB2025	01121	1
A5R3	RESISTOR,FIXED,COMP.,100 OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-101J	HB1015	01121	1
A5R4	RESISTOR,FIXED,COMP.,100 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-101J	EB1015	01121	1
A5R5	RESISTOR,FIXED,COMP.,3.3K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-332J	EB3325	01121	1
A5R6	RESISTOR,FIXED,COMP.,820 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-821J	EB8215	01121	1
A5R7	RESISTOR,FIXED,COMP.,51 OHMS,PORM 5 PCT,1/2W SINGER PART NO. 151-1003-510J	EB5105	01121	1
A5R8	RESISTOR,VARIABLE,100 OHMS,PORM 20 PCT,1/3W, 25T SINGER PART NO. 556147-260	NP101M	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R9	RESISTOR,FIXED,COMP.,160 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-161J	EB1615	01121	1
A5R10	RESISTOR,FIXED,COMP.,2.4 MEGOHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-245J	CB2455	01121	1
A5TT1	INDICATOR,TIME,ELAPSED,CHEMICAL SINGER PART NO. 556147-245	150	18583	1
A6	+180 VOLT/ANODE POWER SUPPLY ASSY	103-1655-001	16665	1
A6CR1 AND CR2	DIODE,SILICON SINGER PART NO. 556146-195	1N4514	INSTD	1
A6CR3	DIODE,ZENER,SILICON,180V,PORM 5 PCT,1W SINGER PART NO. 556147-166	1N3050B	INSTD	1
A6CR4	DIODE,SILICON SINGER PART NO. 556118-046	1N251	INSTD	1
A6CR5	DIODE,ZENER,SILICON,9.1 V,PORM 5 PCT,0.4W SINGER PART NO. 154-0006-001	1N960B	INSTD	1
A6CR6 AND CR7	SAME AS A6CR1			
A6CR8	SAME AS A6CR4			
A6C1	CAPACITOR,FIXED,ELECTROLYTIC,100 UF,350V SINGER PART NO. 556147-172	39D107F350HS4	56289	1
A6C2	CAPACITOR,FIXED,METALLIZED PAPER,0.25 UF, PORM 20 PCT,200 VDCW SINGER PART NO. 150-3002-2542	P8292ZN11	00656	1
A6C3	SAME AS A2A1C6			
A6C4	CAPACITOR,FIXED,MICA,100 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-101FJ0	DM15F101J0500WV4CR	72136	1
A6C5	SAME AS A2A1C6			
A6C6	SAME AS A2A1C2			
A6C7	CAPACITOR,FIXED,METALLIZED PAPER,2 UF,PORM 20 PCT,200VDCW SINGER PART NO. 150-3002-2052	P8292ZN14	00656	1
A6Q1 THRU Q5	TRANSISTOR,SILICON,NPN SINGER PART NO. 556147-124	40327	86684	1
A6Q6 THRU Q9	TRANSISTOR,SILICON,NPN SINGER PART NO. 556146-989	2N3904	INSTD	1
A6R1	RESISTOR,FIXED,COMP.,27K OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-273J	GB2735	01121	1
A6R2 THRU R4	RESISTOR,FIXED,COMP.,51K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-513J	CB5135	01121	1
A6R5 AND R6	RESISTOR,FIXED,COMP.,62K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-623J	CB6235	01121	1
A6R7	RESISTOR,FIXED,COMP.,120K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-124J	CB1245	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A6R8	SAME AS A1A1R1			
A6R9	RESISTOR,FIXED,DEP. CARBON,8K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B8001F	C1/8E8000PORM1PCT	12126	1
A6R10	RESISTOR,FIXED,DEP. CARBON,2K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B2001F	C1/8E2000PORM1PCT	12126	1
A6R11	RESISTOR,FIXED,DEP. CARBON,18K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B1802F	C1/8E18000PORM1PCT	12126	1
A6R12	RESISTOR,FIXED,DEP. CARBON,46.4K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B4642F	C1/8E46400PORM1PCT	12126	1
A6R13	RESISTOR,FIXED,DEP.,CARBON,9.09K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B9091F	C1/8E9090PORM1PCT	12126	1
A6R14	SAME AS A6R12			
A6R15	RESISTOR,FIXED,DEP. CARBON,40K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B4002F	C1/8E40000PORM1PCT	12126	1
A6R16	RESISTOR,FIXED,COMP.,180K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-184J	CB1845	01121	1
A6R17	SAME AS A1A1R1			
A6R18	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP. MTG,100K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 556056-128	XHT201-2/100K,20PCT	11236	1
A6R19	RESISTOR,FIXED,COMP.,1 MEGOHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-105J	CB1055	01121	1
A6R20	RESISTOR,FIXED,DEP. CARBON,780 OHMS,PORM 1 PCT,1/2W SINGER PART NO. 151-1008-B7800F	C1/2K780PORM1PCT	12126	1
A7	SWEPT POWER SUPPLY CONTROL ASSY	103-1656-001	16665	1
A7CR1 THRU CR11	DIODE,SILICON SINGER PART NO. 556146-880	FDH-666	07263	3
A7CR12	DIODE,ZENER,SILICON,6.2V,PORM 5 PCT,0.4W SINGER PART NO. 556147-236	1N753A	INSTD	1
A7CR13 AND CR14	SAME AS A7CR1			
A7C1	SAME AS A2A3C4			
A7C2	CAPACITOR,FIXED,CERAMIC,0.1 UF,PORM 20 PCT, 25VDC SINGER PART NO. 556120-162	5C023104X0250B3	56289	1
A7C3	SAME AS A2A1C2			
A7C4	SAME AS A2A1C8			
A7Q1	TRANSISTOR,SILICON,NPN SINGER PART NO. 556146-254	2N3565	07263	3
A7Q2 AND Q3	SAME AS A5Q3			
A7Q4	SAME AS A7Q1			
A7Q5 AND Q6	TRANSISTOR,MATCHED PAIR	109-0302-001	16665	2

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A7Q7 AND Q8	SAME AS A4Q1			
A7Q9 THRU Q11	SAME AS A7Q1			
A7Q12 THRU Q14	SAME AS A5Q3			
A7Q15 AND Q16	SAME AS A7Q1			
A7R1	RESISTOR,FIXED,COMP.,39 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-390J	CB3905	01121	2
A7R2	RESISTOR,VARIABLE,20K OHMS,PORM 20 PCT,1/3W, 25T SINGER PART NO. 151-0026-203	NP203M	01121	1
A7R3	SAME AS A1A1R2			
A7R4	SAME AS A7R1			
A7R5	SAME AS A7R2			
A7R6	SAME AS A1A1R2			
A7R7	SAME AS A7R1			
A7R8	RESISTOR,VARIABLE,100K OHMS,PORM 20 PCT, 1/3W,25T SINGER PART NO. 151-0026-104	NP104M	01121	2
A7R9	SAME AS A1A1R2			
A7R10	SAME AS A7R1			
A7R11	SAME AS A7R8			
A7R12	SAME AS A1A1R2			
A7R13	SAME AS A7R1			
A7R14	SAME AS A7R8			
A7R15	SAME AS A1A1R2			
A7R16	SAME AS A7R1			
A7R17	SAME AS A7R8			
A7R18	RESISTOR,FIXED,COMP.,20K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-203J	CB2035	01121	1
A7R19	SAME AS A7R1			
A7R20	SAME AS A7R8			
A7R21	SAME AS A7R18			
A7R22	SAME AS A7R1			
A7R23	SAME AS A7R8			
A7R24	SAME AS A7R18			
A7R25	RESISTOR,FIXED,COMP.,180 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-181J	CB1815	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A7R26	RESISTOR,VARIABLE,200K OHMS,PORM 20 PCT, 1/3W,25T SINGER PART NO. 556147-258	NP204M	01121	1
A7R27	RESISTOR,FIXED,COMP.,27K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-273J	CB2735	01121	1
A7R28	RESISTOR,FIXED,COMP.,240 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-241J	GB2415	01121	1
A7R29	RESISTOR,FIXED,METAL FILM,7.69K OHMS,PORM 1 PCT,1W SINGER PART NO. 151-2012-A7691F	M1/2E76900HMSPORM1PC	12126	1
A7R30	SAME AS A1A1R1			
A7R31	SAME AS A2A2R1			
A7R32	SAME AS A2R1			
A7R33	RESISTOR,FIXED,COMP.,510 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-511J	CB5115	01121	1
A7R34	RESISTOR,FIXED,COMP.,11K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-113J	CB1135	01121	1
A7R35	SAME AS A2A3R3			
A7R36	RESISTOR,FIXED,DEP. CARBON,24.3K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B2432F	C1/8E24300PORM1PCT	12126	1
A7R37	SAME AS A2A2R3			
A7R38	RESISTOR,FIXED,DEP. CARBON,15K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B1502F	C1/8E15000PORM1PCT	12126	1
A7R39	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP SINGER PART NO. 556203-006	XHT201-2/25K.20PCT	11236	1
A7R41	SAME AS A1A1R1			
A7R42	RESISTOR,FIXED,COMP.,16K OHMS,PORM 5PCT, 1/4W SINGER PART NO. 151-1002-163J	CB1635	01121	1
A7R43	RESISTOR,FIXED,COMP.,750 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-751J	CB7515	01121	1
A7R44	SAME AS A1A1R1			
A7R45	RESISTOR,FIXED,COMP.,3.9K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-392J	CB3925	01121	1
A7R46	SAME AS A1A1R4			
A7R47	SAME AS A1A1R1			
A7R48	SAME AS R6			
A7R49	RESISTOR,FIXED,COMP.,6.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-622J	CB6225	01121	1
A7R50	SAME AS R7			
A7R51	SAME AS A2A2R5			
A7R52 AND R53	SAME AS A7R42			
A7R54	RESISTOR,FIXED,DEP. CARBON,10K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B1002F	C1/8E10000PORM1PCT	12126	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A7R55	SAME AS A1A1R2			
A7R57	SAME AS A1A1R2			
A7R58	SAME AS A1A1R1			
A7R59	RESISTOR,FIXED,COMP.,22K OHMSPORM 5 PCT, 1/4W SINGER PART NO. 151-1002-223J	CB2235	01121	1
A7R60 AND R61	RESISTOR,FIXED,DEP. CARBON,6810 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B6811F	C1/8E6810PORM1PCT	12126	1
A7R62	SAME AS A1A1R2			
A7R63	SAME AS A2A2R3			
A7R64	SAME AS A1A1R2			
A7R65	SAME AS A7R59			
A7R66	SAME AS A1A1R1			
A7R67	SAME AS A1A1R2			
A7R68 AND R69	SAME AS A7R60			
A7R70	SAME AS A1A1R2			
A7R71	SAME AS A1A1R1			
A7R72	SAME AS A2A2R3			
A7R73	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP. MTG,2.5K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 556146-550	XHT201-2/2.5K,20PCT	11236	2
A7R74	RESISTOR,FIXED,COMP.,5.1K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-512J	EB5125	01121	1
A7R75	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP. MTG,50K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 556056-129	XHT201-2/50K,20PCT	11236	1
A7R76	RESISTOR,FIXED,COMP.,24K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-243J	EB2435	01121	1
A7R77	SAME AS A1A1R1			
A7R78 AND R79	SAME AS A1A1R2			
A8	AUXILIARY CONTROL ASSY	103-1657-001	16665	1
A8CR1	RECTIFIER,SILICON,CONTROLLED,200V,2A,FLAT PACK SINGER PART NO. 556147-237	C106B21	03508	1
A8CR2	SAME AS A7CR12			
A8CR3	SAME AS A7CR1			
A8C1	SAME AS A7C2			
A8C2	SAME AS A2A1C6			
A8C3	CAPACITOR,FIXED,CERAMIC,0.18 UF,PORM 10 PCT, 100 VDCW SINGER PART NO. 150-1016-184	3C067184X9101A	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8C4	SAME AS A2A2C3			
A8Q1 THRU Q4	SAME AS A7Q1			
A8Q5	TRANSISTOR,SILICON,NPN SINGER PART NO. 556146-673	2N3440	86684	1
A8Q6 AND Q7	SAME AS A4Q1			
A8Q8	SAME AS A7Q1			
A8Q9 AND Q10	SAME AS A4Q1			
A8Q11	SAME AS A5Q3			
A8Q12 AND Q13	SAME AS A7Q1			
A8R1	SAME AS A7R34			
A8R2	SAME AS A1A1R1			
A8R3	SAME AS A7R18			
A8R4	SAME AS A1A1R2			
A8R5	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP MTG,100 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 556203-001	XHT201-2/100,20PCT	11236	1
A8R6	SAME AS A1A1R2			
A8R7	SAME AS A1A1R1			
A8R8 AND R9	SAME AS A1A1R2			
A8R10	SAME AS A3R1			
A8R11	RESISTOR,FIXED,COMP.,75K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-753J	CB7535	01121	1
A8R12	RESISTOR,FIXED,COMP.,1.5K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	CB1525	01121	2
A8R13	SAME AS A3R1			
A8R14	RESISTOR,FIXED,COMP.,200 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-201J	CB2015	01121	1
A8R15	SAME AS A7R49			
A8R16	SAME AS A8R11			
A8R17	RESISTOR,FIXED,COMP.,270K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-274J	CB2745	01121	1
A8R18	SAME AS A7R49			
A8R19	SAME AS A2A1R3			
A8R20	RESISTOR,FIXED,COMP.,100K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-104J	CB1045	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8R21 AND R22	SAME AS A7R49			
A8R23 AND R24	SAME AS A8R12			
A8R25	SAME AS A1A1R1			
A8R26	RESISTOR,FIXED,COMP.,5.6K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-562J	CB5625	01121	1
A8R27	SAME AS A1A1R1			
A8R28	SAME AS A7R59			
A8R29	RESISTOR,FIXED,DEP. CARBON,5110 OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B5111F	C1/8E5110PORM1PCT	12126	1
A8R30	SAME AS A7R60			
A8R31	SAME AS A8R12			
A8R32	SAME AS A3R1			
A8R33	SAME AS A2A2R3			
A8R34	SAME AS A1A1R1			
A8R35	SAME AS A1A1R3			
A8R36	SAME AS A2A2R1			
A8R37	RESISTOR,FIXED,COMP.,33K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-333J	CB3335	01121	1
A8R38	SAME AS R6			
A9	-24 VOLT POWER SUPPLY ASSY	103-1674-/01	16665	1
A9CR1 THRU CR4	SAME AS A1CR1			
A9CR5	DIODE,ZENER,SILICON,5.1V,PORM 10 PCT,0.4W SINGER PART NO. 556118-171	1N751	INSTD	1
A9CR6	DIODE,ZENER,SILICON,6.2V,PORM 5 PCT,0.4W SINGER PART NO. 556166-039	1N823A	INSTD	1
A9CR7	SAME AS A1CR1			
A9C1	CAPACITOR,FIXED,ELECTROLYTIC,500 UF,PLUS 150 MINUS 10 PCT,50V SINGER PART NO. 150-5007-027	BR-500-50	93790	1
A9C2	CAPACITOR,FIXED,ELECTROLYTIC,250 UF,30VDCW SINGER PART NO. 556201-102	39D257G030EL4	56289	1
A9C3	CAPACITOR,FIXED,MICA,750 PF,PORM 5 PCT,300V SINGER PART NO. 150-2002-751FJ0	DM15F751J0500WV4CR	72136	1
A9C4	SAME AS A2A1C4			
A9C5	CAPACITOR,FIXED,ELECTROLYTIC,5 UF,PLUS 75 MINUS 10 PCT,25VDC SINGER PART NO. 150-5001-5R0FS	TE-1303	56289	1
A9C6	CAPACITOR,FIXED,MICA,200 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-201FJ0	DM15F201J0500WV4CR	72136	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9C7	CAPACITOR,FIXED,CERAMIC DISC,5000 PF GMV, 1000V SINGER PART NO. 556060-145	1KV/5000PFGMV	91418	1
A9C8	CAPACITOR,FIXED,ELECTROLYTIC,50 UF,PLUS 75 MINUS 10 PCT,50VDC SINGER PART NO. 150-5001-500FS	TE-1307	56289	1
A9MC1 AND MC2	INTEGRATED CIRCUIT,OPERATIONAL AMPLIFIER SINGER PART NO. 556146-992	UA709C/U5B770939X	07263	1
A9Q1	TRANSISTOR,SILICON,PNP SINGER PART NO. 153-0006-001	2N4918	04713	1
A9Q2 THRU Q4	TRANSISTOR,SILICON,PNP SINGER PART NO. 556146-988	2N3906	INSTD	2
A9R1	RESISTOR,FIXED,COMP.,470 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-471J	EB4715	01121	1
A9R3	RESISTOR,FIXED,COMP.,8.2 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-8R2J	CB8R25	01121	1
A9R4	SAME AS A8R12			
A9R5	SAME AS A4R7			
A9R6 AND R7	RESISTOR,FIXED,METAL FILM,2.87K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-2871	PME60/T-0/2870/PORM1	03888	1
A9R8	RESISTOR,VARIABLE,MINIATURE TRIM,PC PERP. MTG,1K OHM,PORM 20 PCT,1/4W SINGER PART NO. 556056-124	XHT201-2/1K,20PCT	11236	1
A9R9	RESISTOR,FIXED,METAL FILM,8.25K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-2014-8251	PME60/T-0/8250/PORM1	03888	1
A9R11	SAME AS A2A2R3			
A9R12	RESISTOR,FIXED,COMP.,22 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-220J	CB2205	01121	1
A9R13	SAME AS A8R12			
A9R14	RESISTOR,FIXED,COMP.,470 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-471J	CB4715	01121	1
A9R15 AND R16	RESISTOR,FIXED,METAL FILM,1K OHM,PORM 1 PCT, 1/4W SINGER PART NO. 151-2014-1001	PME60/T-0/1000/PORM1	03888	1
A9R17	SAME AS A2R1			
A9R18	SAME AS A8R12			
A10	TUNING LIMIT CONTROL ASSY	103-1673-001	16665	1
A10C1 AND C2	CAPACITOR,FIXED,METALLIZED PAPER,1 UF,PORM 10 PCT,50VDCW SINGER PART NO. 150-3003-004	1PP5DK	02777	1
A10C3	SAME AS A2A1C2			
A10Q1	TRANSISTOR,SILICON,NPN,DARLINGTON SINGER PART NO. 153-0001-001	2N5306	INSTD	1
A10Q2 THRU Q4	SAME AS A9Q2			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A10R1	SAME AS A8R20			
A10R2	SAME AS A3R1			
A10R3	RESISTOR,FIXED,DEP. CARBON,16.2K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B1622F	C1/8E16200PORM1PCT	12126	1
A10R4	RESISTOR,FIXED,DEP. CARBON,82.5K OHMS,PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B8252F	C1/8E82500PORM1PCT	12126	1
A10R5 AND R6	SAME AS A6R5			
A10R7	SAME AS A1A1R1			
A10R8	SAME AS A7R18			
A10R9	RESISTOR,VARIABLE,MINIATURE TRIM,100K OHMS, PORM 10 PCT,3/4W SINGER PART NO. 151-0025-104	156-2/100K	75042	1
A10R10	RESISTOR,VARIABLE,MINIATURE,10K OHMS,PORM 5 PCT,1W SINGER PART NO. 151-0024-103	106-2/10K	75042	1
A10R11 THRU R17	SAME AS A7R73			
A11	29 MHZ PULLED OSCILLATOR ASSY	103-1748-001	16665	1
A11C1	CAPACITOR,VARIABLE,3.2 TO 36 PF	132-0315-001	16665	1
A11C2	SAME AS A1A1C4			
A11C3	SAME AS A2A1C6			
A11C4	CAPACITOR,FIXED,MICA,27 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-270FGO	DM15F270G0500WV4CR	72136	1
A11C5	SAME AS A2A2C2			
A11C6	SAME AS A2A1C1			
A11C7	CAPACITOR,FIXED,ELECTROLYTIC,35 UF,PLUS 75 MINUS 10 PCT,15VDC SINGER PART NO. 150-5001-350DS	TE-1159	56289	1
A11C8	SAME AS A2A1C6			
A11FL1	SAME AS A1A1FL1			
A11L1	INDUCTOR,FIXED	132-0309-001	16665	1
A11P1	SAME AS J12			
A11Q1	TRANSISTOR,SILICON,PNP SINGER PART NO. 556146-923	2N4917	07263	1
A11R1	SAME AS A7R49			
A11R2	SAME AS A1A1R1			
A11R3 AND R4	SAME AS A2A1R2			
A11R5	RESISTOR,FIXED,COMP.,47 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-470J	CB4705	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A11J1	CONNECTOR,COAXIAL,BULKHEAD RECEPTACLE,SUB-MINIATURE SNAP-ON TYPE SINGER PART NO. 168-4027-001	51-043-4300	98291	1
A11T1	TRANSFORMER,RF,TUNABLE	132-0308-001	16665	1
A11Y1	CRYSTAL,QUARTZ,29.15 MHZ,IN HC-6/U HOLDER	134-0053-001	16665	1
A12	PHASE LOCK BRACKET ASSY	103-1810-001	16665	1
A12AT1 AND AT2	SAME AS A1AT5			
A12AT1J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A12AT1			
A12AT1P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A12AT1			
A12AT2J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A12AT2			
A12AT2P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A12AT2			
A12AT3	ISOLATOR,4 TO 8 GHZ	556147-208	16665	1
A12AT3J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A12AT3			
A12AT3P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A12AT3			
A12CR1	DIODE,SILICON SINGER PART NO. 556146-342	1N1132	INSTD	1
A12DC1	DIRECTIONAL COUPLER ASSY	103-1762-001	16665	1
A12DC1J1	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A12DC1	103-1762-001	16665	1
A12FL1	4 GHZ HIGH-PASS FILTER ASSY	103-1769-001	16665	1
A12FL1J1 AND J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A12FL1			
A12P1	CONNECTOR,PLUG,ELEC.,MALE,5 PINS,W/HOOD AND CLAMP SINGER PART NO. 556016-087	126-217	02660	1
A12W1	SAME AS A1W2			
A12W1P1 AND P2	SAME AS W1P2			
A12W2	CABLE ASSY	102-9112-003	16665	1
A12W2P1 AND P2	SAME AS W1P2			
A12W3	SAME AS A1W2			
A12W3P1 AND P2	SAME AS W1P2			
A12XCR1	CRYSTAL HOLDER ASSY	103-1763-001	16665	1
A12XCR1J1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A12XCR1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A12A1	COMB GENERATOR ASSY	103-1747-001	16665	1
A12A1CR1	DIODE,STEP RECOVERY SINGER PART NO. 556147-187	VAS-11BEP	88236	1
A12A1C2	SAME AS A2A1C6			
A12A1C3	SAME AS A1A2C2			
A12A1C4	SAME AS A2A2C3			
A12A1C5	SAME AS A2A1C6			
A12A1C6	SAME AS A2A1C4			
A12A1C7	SAME AS A2A1C6			
A12A1FL1	SAME AS A1A1FL1			
A12A1J1	SAME AS A11J1			
A12A1J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PART OF A12A1			
A12A1L1	SAME AS A2A2L1			
A12A1Q1	TRANSISTOR,SILICON,NPN SINGER PART NO. 556147-003	2N4427	86684	1
A12A1R1	RESISTOR,FIXED,COMP.,15 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-150J	CB1505	01121	1
A12A1R2	RESISTOR,FIXED,COMP.,68 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-680J	CB6805	01121	1
A12A1R3	SAME AS A12A1R1			
A12A1R4	SAME AS A7R74			
A12A1R5	SAME AS R35			
A12A1R6	RESISTOR,FIXED,COMP.,22 OHMS,PORM 5 PCT, 1W SINGER PART NO. 151-1004-220J	GB2205	01121	1
A12A1R7	RESISTOR,FIXED,COMP.,5.6 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-5R6J	EB5R65	01121	1
A12A1R8	RESISTOR,FIXED,COMP.,220 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-221J	EB2215	01121	1
A12A1R9	SAME AS A12A1R7			
A12A1R10	SAME AS A2A1R2			
A12A1T1	TRANSFORMER,RF,TUNABLE	132-0310-001	16665	1
A12A2	21 MHZ AMPLIFIER ASSY	103-1764-001	16665	1
A12A2CP1	CONNECTOR AND MIXER ASSY	103-1619-001	16665	1
A12A2C1 AND C2	SAME AS A2A1C4			
A12A2C3	SAME AS A2A2C3			
A12A2C4	CAPACITOR,FIXED,MICA,15 PF,PORM 5 PCT,500VDC SINGER PART NO. 150-2002-150CJ0	DM15C150J0500WV4CR	72136	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A12A2C5	CAPACITOR,FIXED,MICA,56 PF,PORM 2 PCT,500V SINGER PART NO. 150-2002-560EGO	DM15E560GO500WV4CR	72136	1
A12A2FL1	SAME AS A1A1FL1			
A12A2J1	CONNECTOR,COAXIAL,RIGHT ANGLE BULKHEAD RE-RECEPTACLE,MINIATURE SCREW-ON TYPE,MALE SINGER PART NO. 556010-267	51-047-0000	98291	1
A12A2L1	INDUCTOR,VARIABLE	132-0289-001	16665	1
A12A2L2	SAME AS A2A2L1			
A12A2Q1	SAME AS A2A1Q1			
A12A2R1	SAME AS A2A1R5			
A12A2R2	SAME AS A1A1R2			
A12A2R3	SAME AS A2A2R3			
A12A2R4	SAME AS A1A1R1			
A12A2R5	SAME AS A2A3R5			
A12A2R6	SAME AS A1A1R1			
A12A2R7	RESISTOR,FIXED,COMP.,18 OHMS,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-180J	CB1805	01121	1
A12A2R8	SAME AS A12A1R2			
A12A2R9	SAME AS A12A1R7			
A12A2R10	SAME AS A2A3R3			
A13	RF MARKER ASSY	103-1768-001	16665	1
A13CP1	MIXER ASSY	134-0018-001	16665	1
A13CP1J1 AND J2	CONNECTOR,COAXIAL,TYPE TNC,FEMALE NON-REPLACEABLE PARTS OF A13CP1			
A13CP2	CRYSTAL HOLDER ASSY	135-0078-001	16665	1
A13CP2J1	CONNECTOR,COAXIAL,BULKHEAD RECEPTACLE,TYPE TNC,FEMALE	149-0068-001	16665	1
A13CR1	DIODE,SILICON SINGER PART NO. 556118-035	1N358A	93332	1
A13W1	SAME AS A1W5			
A13W1P1 AND P2	SAME AS W1P2			
A13W2	CABLE ASSY	103-1901-001	16665	1
A13W2P1	CONNECTOR,COAXIAL,TYPE TNC,MALE NON-REPLACEABLE PART OF A13W2			
A14	SERVICE EXTENDER ASSY	103-1672-001	16665	1
A14P1	CONNECTOR,RECEPTACLE,FEMALE,44 CONTACTS,PC CARD TYPE SINGER PART NO. 168-3002-107	81-6044-1107-00	95354	1
A15	SWITCH ASSY	556147-088	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A16	SWITCH ASSY	556147-089	16665	1

WARRANTY CLAIM AND ADJUSTMENT PROCEDURE

for microwave tubes supplied by
The Singer Company
Instrumentation Division
for use in The Singer Co. instruments

The procedure described below is for use within the United States. For warranty claims arising outside the U.S.A., before returning the tube, fill out the form on the reverse side and send it with a request for shipping instructions to your nearest Singer Company, Instrumentation Division Sales and Service Office or to:

(in Western Europe)

Instrumentation Division
The Singer Sewing Machine Co.
P.O. Box 301
8034 Zurich, Switzerland
Attention: R. M. Lewis
Telephone (051)47.25.10
Telex 53.245

(Rest of World)

The Singer Company
Instrumentation Division
915 Pembroke Street
Bridgeport, Connecticut 06608
Telephone (203) 366-3201

Microwave tubes supplied by The Singer Company, Instrumentation Division, either as original or replacement, for use in The Singer Co. instruments are actually warranted by the tube manufacturer and not by The Singer Co. However, all warranty claims on tubes obtained from us either as original or replacement will be processed by The Singer Co., Instrumentation Div.

In the event of failure you should purchase a new tube immediately without regard to first returning the defective tube to The Singer Co. because old tubes will not be repaired. Credit allowances will be passed on to you upon receipt and inspection of the defective tube.

Note: If credit allowance is claimed the defective tube must be returned within six weeks of the actual date of failure.

For your convenience, warranty claims for all microwave tubes supplied by The Singer Company may be made on this single form; merely fill out the information on the reverse side and return this form, along with the defective tube, to your Singer Co., Instrumentation Division Sales and Service Office or to The Singer Co. Please be sure each space on the form is filled in--lack of complete information may delay processing of your claim.

MICROWAVE TUBE WARRANTY CLAIM
INFORMATION FORM

IMPORTANT: Please answer all questions fully -- insufficient information may delay processing of your claim.

FROM: (Tube Owner)

Company _____

Address _____

_____

_____

Tube type _____

Tube serial No._____

Tube Mfr._____

Used in the Singer Co. Model_____

Instrument serial no._____

Tube is original( ) or
replacement ( )

Date tube received_____

Date first tested_____

Date placed in service_____

Date of failure_____

Date_____

FOR FURTHER INFORMATION CONTACT:

Name_____

Title_____

Company_____

Address_____

Telephone No._____

Tube purchase from_____

_____

On P.O. number_____

Hours use per day (average)____

Number of days in service_____

Total hours filament or heater operation_____

Total hours of beam Voltage applied to tube_____

SYMPTOMS: (Please describe conditions prior to and at time of failure, along with description of tube's defect, if known)_____

_____

_____

_____

Were there other circuit component failures at time of failure?
Which ones?_____

_____

Signature_____

Title _____

SHIPPING INSTRUCTIONS

The following instructions are included to aid you in preventing damage in transit. Package your tube carefully--no allowance can be made on broken tubes.

1. Carefully wrap tube in 1/4-inch thick cellulosic cushioning, cotton batting, or other soft padding material. Cable assemblies and other accessories not rigidly mounted to the tube should be padded and wrapped separately to prevent damage to the tube during shipment.

2. Remove total time indicator TT1 from -6.1 Volt BWO Filament Power Supply A5. Package in suitable container to prevent loss or damage in transit. Pad, wrap and identify elapsed time meter package, Tape tube and meter packages together and wrap in heavy Kraft paper.

3. Pack in a rigid container which is at least 6 inches larger than the tube in each dimension.

4. Surround the tube with at least 4 inches of shock absorbing material. Be certain that the packing is tight all around the tube.

5. Tubes returned from outside the continental United States should be packed in a wooden box.

6. Mark container FRAGILE and ship prepaid via Airfreight or Railway Express. Do not ship via Parcel Post or Air Pacel Post since experience has shown that fragile items are more apt to be damaged when shipped by these means.

NOTE

Tubes with permanent magnets can interfere with magnetic compasses. For air shipment plainly mark container: "MAGNETIZED MATERIAL"

In-warranty tubes purchased from The Singer Company may be returned, with a completed Warranty Claim Form, to:

The Singer Company
Instrumentation Division
915 Pembroke Street
Bridgeport, Connecticut 06608

INSTRUCTION MANUAL

MAIN FRAME

MODEL MF-100

Instruction Manual No. 110-5079

Serial No. _____

SINGER
INSTRUMENTATION

THE SINGER COMPANY • INSTRUMENTATION DIVISION

Creative Products for Test, Measurement, Analysis, Calibration

ADDENDUM

for

MODEL MF-100

(Effective on equipment serial numbered U30730 and up.)

I. PURPOSE.

To improve equipment operation.

II. ADDENDUM.

a. In figure 5-5, change the value of L5 from 1uH to 0.68uH.

b. In figure 5-17, add R113 (51 ohms) between the emitter of Q30 and the junction of R78 and terminal 7.

c. In table 6-2, incorporate the following entries:

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A3L4 and L5	COIL, RF, 0.68UH SINGER P/N 556012-013	CLA-0.68PORM 10 PCT	75042	1
A5R113	SAME AS R50			

ADDENDUM

for

MODEL MF-100

(Effective on equipment serial numbered U31054 and up.)

I. PURPOSE.

To improve equipment operation.

II. ADDENDUM.

a. In figure 5-20, change the value of R11 from "10K, 1/2W" to read "9.09K, 1%."

b. Incorporate the changes listed below into table 6-2.

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9	AUXILIARY CONTROL ASSY	103-1574-003	16665	1
A9R11	RESISTOR,FIXED,METAL FILM,9090 OHMS,PORM 1 PCT,1/4W SINGER P/N 151-2014-9091	PME60/T-0/9090 /PORM1PCT	03888	1

Addendum No. 615

ADDENDUM

for

MODEL MF-100

(Effective on equipment serial numbered U31054 and up.)

I. PURPOSE.

To improve equipment operation.

II. ADDENDUM.

a. In figure 5-20, change the value of R11 from "10K, 1/2W" to read "9.09K, 1%."

b. Incorporate the changes listed below into table 6-2.

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9	AUXILIARY CONTROL ASSY	103-1574-003	16665	1
A9R11	RESISTOR,FIXED,METAL FILM,9090 OHMS,PORM 1 PCT,1/4W SINGER P/N 151-2014-9091	PME60/T-0/9090 /PORM1PCT	03888	1

Addendum No. 615

ADDENDUM

for

MODEL MF-100

(Effective on equipment serial numbered U31292 and up)

I. PURPOSE.

To improve equipment operation.

II. ADDENDUM.

a. In table 1-2:

(1) Change the type and function for CR1 through CR4 of A2A7 to read "132-0376-001 (Singer)" and "Balanced mixer diode quad," respectively.

(2) Delete "Q4," "2N3563" and "60-MHz amplifier" from the complement of A2A7.

(3) Change "Q1 and Q2" of A2A8 to read "Q1".

(4) Add "Q2," "3N140" and "60-MHz amplifier" to the complement of A2A8.

b. In figure 3-2 (sheet 1):

(1) Delete the block representing 60 MHz Amplifier A2A7Q4 and associated transformer A2A7T2.

(2) Delete adjustments A2A7R14 and A2A7C11 from the block representing balanced mixer A2A7CR1-CR4.

(3) Show the output of balanced mixer A2A7CR1-CR4 going to A2A7J2.

c. Delete the last two sentences of paragraph 3-13.

d. Change the first sentence of paragraph 3-14 to read: "The output of the balanced mixer is applied to 60 MHz amplifier A2A8Q2."

e. Change the third sentence of paragraph 3-22 to read: "...wideband local oscillator A2A7Q3 and narrowband local oscillator A2A7Q5."

f. Change step c of paragraph 4-21 to read: "Tune A2A3C8, A2A3L2, A2A3L3, A2A3C17 and..."

g. Change the last sentence of paragraph 4-24, step d, to read: "...be 3 dB or less."

h. In paragraph 4-25:

(1) Delete steps c and d.

(2) Change steps e through r to read steps c through p, respectively.

(3) Change step s to read: "q. Disconnect the equipment from the setup of figure 4-20 and rotate the MARKER LEVEL control fully counterclockwise to OFF."

(4) Change step t to read step r.

(5) Delete steps u through x.

(6) Change step y to read: "s. Set the FREQUENCY DISPERSION switch to 10 MHz/DIV, set the AMPLITUDE SCALE switch to LIN and..."

(7) Change steps z and aa to read steps t and u, respectively.

(8) Change step ab to read: "v. Adjust the signal generator for minimum output level."

(9) Change steps ac and ad to read steps w and x, respectively.

i. In paragraph 4-26, change the first sentence of step c to read: "Adjust A2A8C23, A2A8L4 and A2A8L1 to obtain..."

j. In table 4-9

(1) Change the nominal emitter, base and collector voltages of Q2 and Q3 to read: "+5.4," "+6.0" and "+9.0," respectively.

(2) Change the nominal emitter, base and collector voltages of Q4 to read: "+5.4," "6.0" and +9.5," respectively.

k. In table 4-10, delete the entry for Q4.

1. Change table 4-11 to read as shown below.

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	+5.1	+5.8	+11.6
Q3	SE5001	-1.15	-0.43	+4.0
Q4	2N3563	+5.3	+6.0	+11.7

		Nominal Source Voltage	Nominal Drain Voltage	Nominal Gate 1 Voltage	Nominal Gate 2 Voltage
Q2	3N140	+2.0	+12	0	+6.0

m. In table 6-1, add the following

INSTD Industry Standard

n. In table 6-2:

(1) Delete the entries for the following: A2A4R1, A2A4R2, A2A4R3, A2A6R4, A2A6R5, A2A6R6, A2A7C13, A2A7C14, A2A7Q4, A2A7R16, A2A7R17, A2A7R18, A2A7T1, A2A7T2, A2A7T3, A2A8C5, A2A8R11 and A2A8R12.

(2) Change the following entries of table 6-2 to read as indicated below.

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R3	RESISTOR, VARIABLE, 10K OHMS, PORM 10 PCT, 2W, LINEAR SINGER P/N 151-0001-055	GW7224	01121	1
A2	FRONT IF ASSY	103-1584-003	16665	1
A2A3	160-MHz WIDEBAND AMPLIFIER ASSY	103-1554-003	16665	1
A2A3C8	SAME AS A2A1C19			
A2A3C15	SAME AS C1			
A2A3C16	SAME AS A2A3C4			
A2A3L4 and L5	COIL, RF, 0.68UH SINGER P/N 556012-013	CLA-0.68PORM 10PCT	75042	1

Ref Symbol	Description	Manuafacturer's Part Number	Mfr's Code	Maint Qty
A2A3R9 and R10	SAME AS R19			
A2A3R13	SAME AS A2A3R5			
A2A3R17	SAME AS A2A3R5			
A2A3R20	RESISTOR, FIXED, COMP., 62 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-620J	CB6205	01121	1
A2A3R21	SAME AS A2A3R7			
A2A3R22	RESISTOR, FIXED, COMP., 82 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-820J	CB8205	01121	1
A2A3R23	RESISTOR, FIXED, COMP., 560 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-561J	CB5615	01121	1
A2A4	HIGH-PASS FILTER ASSY	103-1555-003	16665	1
A2A4R4	RESISTOR, FIXED, COMP., 30 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-300J	CB3005	01121	2
A2A4R6	SAME AS A2A4R4			
A2A6	LOW-PASS FILTER ASSY	103-1557-003	16665	1
A2A6R1	RESISTOR, FIXED, COMP., 1.5K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-152J	CB1525	01121	3
A2A6R3	SAME AS A2A6R1			
A2A7	WIDEBAND/NARROWBAND SWEPT OSCILLATOR ASSY	103-1558-003	16665	1
A2A7CR1 thru CR4	DIODE QUAD	132-0376-001	16665	1
A2A7C9	SAME AS C1			
A2A7C10	CAPACITOR, FIXED, MICA, 18 PF, PORM 5 PCT, 500V SINGER P/N 150-2002-180CJO	DM15C180JO 500WV4CR	72136	1
A2A7C11	CAPACITOR, FIXED, DIPPED MICA 30 PF, PORM 5 PCT, 500V SINGER P/N 150-2002-300EJO	DM15E300JO 500WV4CR	72136	1

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A7C12	CAPACITOR, FIXED, DIPPED MICA, 110 PF, PORM 5 PCT, 500V SINGER P/N 150-2002-111FJO	DM15F111JO 500WV4CR	72136	1
A2A7C15	CAPACITOR, FIXED, COMP., 2.4 PF, PORM 5 PCT, 500V SINGER P/N 150-4001-2R4J	GA2.4PF PORM5PCT	78488	1
A2A7L7 and L8	INDUCTOR	132-0369-001	16665	1
A2A7L9	INDUCTOR	132-0367-001	16665	1
A2A7L10	INDUCTOR	132-0368-001	16665	1
A2A7R13	RESISTOR, FIXED, COMP., 56 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-560J	CB5605	01121	1
A2A7R14	RESISTOR, FIXED, COMP., 75 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-750J	CB7505	01121	1
A2A7R15	SAME AS R50			
A2A8	60-MHz IF AMPLIFIER ASSY	103-1559-003	16665	1
A2A8C6	CAPACITOR, FIXED, MICA, 10 PF, PORM 5 PCT, 500V SINGER P/N 150-2002-100CJO	DM15C100JO 500WV4CR	72136	1
A2A8C7 thru C9	SAME AS C1			
A2A8C10	SAME AS A2A7C6			
A2A8C11 thru C15	SAME AS C1			
A2A8C23	SAME AS A2A1C19			
A2A8C24 and C25	SAME AS C1			
A2A8C26	CAPACITOR, FIXED, DIPPED MICA, 22 PF, PORM 5 PCT 500V SINGER P/N 150-2002-220EJO	DM15E220JO 500WV4CR	72136	1

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A8L3	INDUCTOR	132-0370-001	16665	1
A2A8Q1	SAME AS A2A1Q1			
A2A8Q2	TRANSISTOR, FET, DUAL GATE SILICON N-CHANNEL SINGER P/N 153-0008-001	3N140	INSTD	1
A2A8R1	RESISTOR, FIXED, COMP., 300 OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-301J	CB3015	01121	1
A2A8R3	SAME AS A2A8R1			
A2A8R5 and R6	SAME AS R13			
A2A8R7	SAME AS R35			
A2A8R8	SAME AS A2A7R4			
A2A8R9	SAME AS R35			
A2A8R10	SAME AS A2A1R16			
A2A8R13	SAME AS A2A8R1			
A2A8R14	SAME AS A2A1R1			
A2A8R15	SAME AS A2A3R23			
A2A9C5	SAME AS A2A7C11			
A3A1R2	SAME AS A2A4R4			
A3A1R4	SAME AS A2A6R1			
A3A1R6	SAME AS A2A6R1			
A3A3R10	SAME AS A2A6R1			
A3A3R24	SAME AS A2A3R22			
A3A4R5	SAME AS A2A3R23			
A3A4R13	SAME AS A2A3R23			
A3A4R20	SAME AS A2A3R23			

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4R27	SAME AS A2A3R23			
A3A4R38	SAME AS A2A3R23			
A3A4R45	SAME AS A2A3R23			
A3A5C7	SAME AS A2A7C11			
A3A5R4	SAME AS A2A8R1			
A3A5R14	SAME AS A2A6R1			
A3A5R21	RESISTOR, VARIABLE, 500 OHMS PORM 20 PCT, 1/4W SINGER P/N 151-0021-002	UHT201-2/500 20PCT	11236	1
A5R3	SAME AS A2A6R1			
A5R10	RESISTOR, FIXED, COMP., 18K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-183J	CB1835	01121	1
A5R15	SAME AS A2A6R1			
A5R41	SAME AS A5R10			
A5R45	SAME AS A5R10			
A5R50	SAME AS A5R10			
A5R54	SAME AS A5R10			
A5R58	SAME AS A5R10			
A5R62	SAME AS A5R10			
A5R65	SAME AS A5R10			
A5R67	SAME AS A5R10			
A5R72	SAME AS A5R10			
A5R76	SAME AS A5R10			
A5R78	SAME AS A2A6R1			
A5R84	SAME AS A5R10			
A5R87	SAME AS A5R10			

Ref Symbol	Description	Manufacturer's Part Number	Mf'rs Code	Maint Qty
A5R90	SAME AS A2A6R1			
A5R93	SAME AS A2A6R1			
A5R100	SAME AS A5R10			
A5R103	SAME AS A2A6R1			
A5R108	SAME AS A2A6R1			
A8R13	SAME AS A2A3R23			
A8R19	SAME AS A3A4R21			
A8R22	SAME AS A2A3R23			
A8R28	SAME AS A2A5R21			

Addendum No. 618

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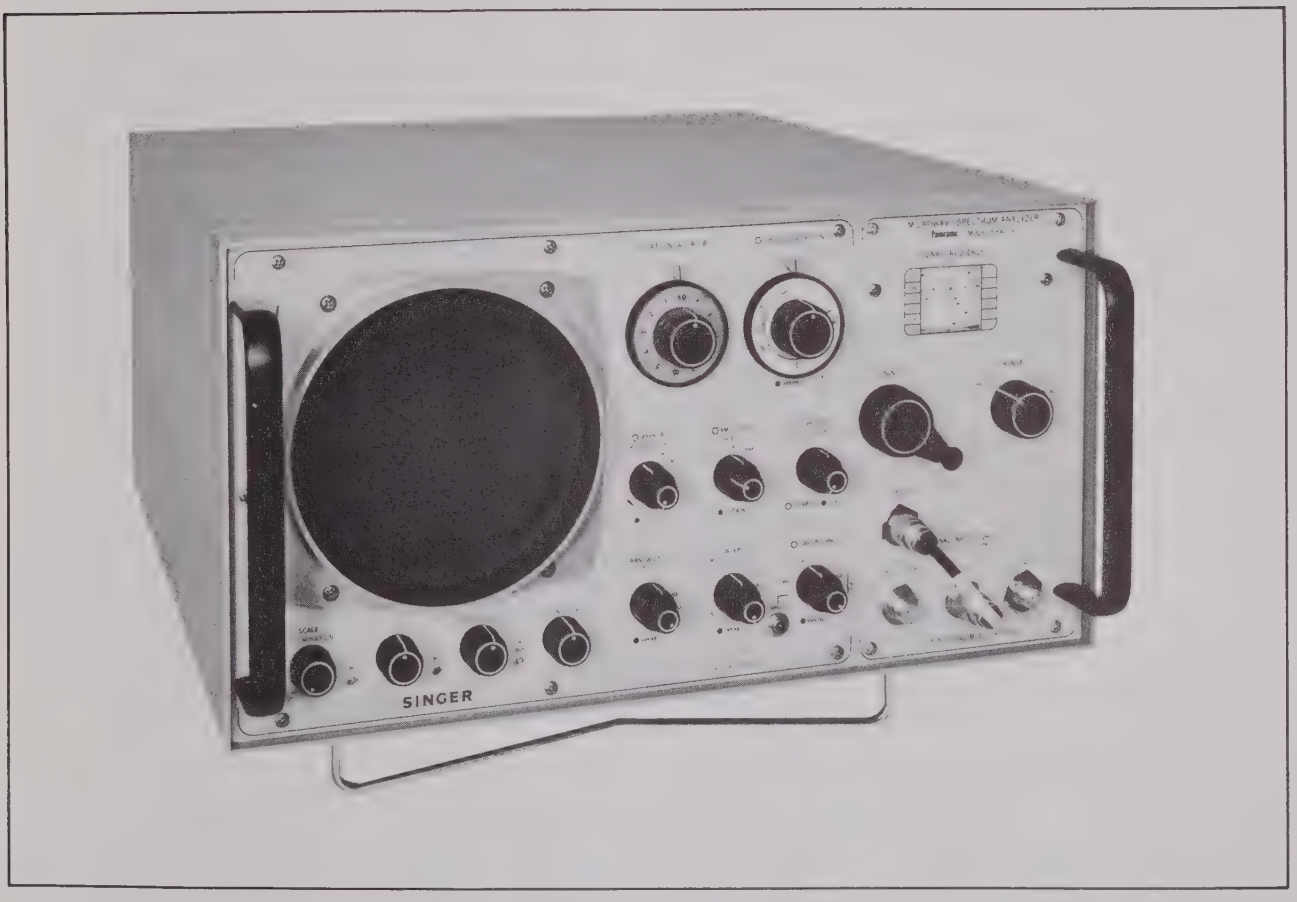

Figure 1-1. Model MF-100 Main Frame with
Model RF-100 Tuning Head Installed

SECTION I
INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides general information, theory of operation and maintenance instructions for the Model MF-100 Main Frame portion (see figure 1-1) of the PANORAMIC* Model SPA-100, SPA-100A and SPA-3000 Microwave Spectrum Analyzers, manufactured by The Singer Company - Metrics Division.

Note

The operating instructions for the Model MF-100 Main Frame is incorporated into the operating instructions of the applicable Tuning Head (Model RF-100, RF-100A or RF-3000) which constitutes the particular microwave spectrum analyzer system. These instructions are contained in the appropriate manual within the front half of this volume.

1-3. The information contained in this handbook reflects the standard Model MF-100 Main Frame (hereafter referred to as the Main Frame) and is current only to the date of publication. Differences in equipment configuration, components, specifications and performance resulting from customer application requirements and/or The Singer Company's continuous product improvement program are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The Main Frame is the display section of the spectrum analyzer. When used in conjunction with associated Tuning Heads, the Main Frame enables the user to visually examine the amplitude-frequency characteristics of applied signals (spectrum analyzer mode of operation) as well as the amplitude-time characteristics (synchroscope mode of operation).

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1-6. The wide variety of calibrated amplitude scales, i-f bandwidths, dispersions, sweep speeds and attenuators plus the selectable synchronization capabilities makes the spectrum analyzer an invaluable tool in the analysis of r-f signals. Some typical applications of the equipment are listed below.

a. Nanosecond pulse analysis.

b. CW, AM, FM, pulse and random noise analysis.

c. Accurate modulation index and deviation measurement of frequency-modulated signals.

d. Intermodulation distortion measurements.

e. Stability measurements of r-f sources.

f. Simplified tuning of frequency multipliers.

g. RFI and EMC spectrum monitoring.

h. Measuring close-in spurious and noise of r-f sources.

1-7. SPECIFICATIONS.

1-8. The electrical and physical specifications of the Main Frame (independent of associated Tuning Heads) are listed in table 1-1.

1-9. ELECTRON TUBE, TRANSISTOR, DIODE AND FUSE COMPLEMENT.

1-10. The types and functions of the entire complement of electron tubes, transistors and diodes employed in the Main Frame are listed in table 1-2; the fuse complement is listed in table 1-3.

TABLE 1-1. SPECIFICATIONS

Parameter	Specification
Signal input	100-MHz band of frequencies centered at 160 MHz
Input impedance	50 ohms
Display dispersion:	
Range	Seven calibrated steps from 10 kHz to 100 MHz in 1-3-10 sequence, continuously adjustable between steps; zero-dispersion capability for receiver or synchroscope operation
Accuracy	±5%

TABLE 1-1. SPECIFICATIONS (Cont'd)

Parameter	Specification
Markers (auto calibration):	
Internal	160-MHz center frequency marker either alone or with selectable 1- and 10-MHz sideband modulation capability
External	1-kHz to 1-MHz sideband modulation capability of internal 160-MHz center frequency marker
Signal attenuation:	
Range	0 to 69 dB in 1-dB steps
Accuracy	±0.05 dB/dB
Intermediate frequencies	60 and 6.5 MHz
Bandwidths:	
Fixed	Six calibrated steps of 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 1MHz and AUTO (automatically selects bandwidth for optimum CW resolution)
Variable	1 to 100 kHz, continuously adjustable
Video filter	Tracked with variable bandwidth, independently adjustable in calibrated bandwidth step positions
Variable i-f gain	20 dB (minimum)
Amplitude scales:	
Logarithmic	60 dB (on screen); accuracy ±2 dB
Linear	Relative voltage; accuracy ±3% of full scale
Power (square law)	Relative power; accuracy ±5% of full scale
CRT	5ADP31M
Graticule	7.5 cm high x 10 cm wide
Sweep modes	Internal, external, manual or single sweep
External sweep input	-5 to +5 volts for full sweep
Sweep time	Eleven calibrated steps from 10 usec/ division to 1 second/ division in 1-3-10 sequence, continuously adjustable between steps; vernier extends slowest time to at least 3 seconds/ division
Spectrum analyzer mode	3 milliseconds/division to 1 second/division
Synchroscope mode	10 usec/division to 1 millisecond/division
Synchronization	Free-running, line, internal or external
External sync level	+3 volts (minimum)
Intensifier	Baseline clipper for brighter display of narrow pulses

TABLE 1-1. SPECIFICATIONS (Cont'd)

Parameter	Specification
Auxiliary outputs:	
Vertical output	0 to +1 volt (nominal); source impedance 1000 ohms
Horizontal output	-0.5 to +0.5 volts (nominal); source impedance 1000 ohms
Predetected 60 MHz output	5-MHz bandwidth
Power requirements	115 or 230 vac (±10%), 47 to 440 Hz, 70 watts
Size (rack mount)	16-3/4" wide x 8-23/32" high x 19-1/2" deep
Weight	50 pounds

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Main Chassis		
CR1	1N821	Clipper
Q1	2N3613	Series regulator
Q2 and Q3	2N3613	D-c amplifiers
Q4	2N3613	Series regulator
Q5	MJ2252 (Motorola)	Series regulator
V1	5ADP31M	CRT
Marker Oscillator A2A1		
CR1 through CR4	1N34A	Balanced mixer
Q1	2N3563	160-MHz oscillator
Q2	2N3563	Amplifier
Q3	2N3563	10-MHz oscillator
Q4	2N3565	1-MHz oscillator
Marker Level A2A2		
CR1 and CR2	FDH666 (Fairchild)	Variable attenuator
160-MHz Wideband Amplifier A2A3		
Q1 through Q3	S24058 (Fairchild)	160-MHz amplifiers
Q4	S24058 (Fairchild)	Emitter follower

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Swept Oscillator A2A7		
CR1 through CR4	1N82AG	Balanced mixer
CR5	FDH666 (Fairchild)	Clamp
CR6	1N942A	Voltage regulator
Q1	2N3642	Adder
Q2	132-0317-001 (Singer-Metrics)	Shaping amplifier
Q3	2N3563	Wideband swept oscillator
Q4	2N3932	60-MHz amplifier
Q5	2N3563	Narrowband swept oscillator
Q6	SE7010 (Fairchild)	Shaping amplifier
Q7	2N3565	Adder
60-MHz I-f Amplifier A2A8		
Q1 and Q2	2N3563	60-MHz amplifiers
Q3	SE5001 (Fairchild)	60-MHz amplifier
Q4	2N3563	60-MHz amplifier
60-MHz to 6.5-MHz Converter A2A9		
Q1	2N3563	53.5-MHz oscillator
Q2	2N3563	Mixer
6.5-MHz Wideband Filter A3A1		
CR1 through CR4	1N251	Diode switches
Q1	2N3563	6.5-MHz amplifier
6.5-MHz Narrowband Filter A3A2		
Q1	2N3694	6.5-MHz amplifier
Q2	2N3694	Emitter follower

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
6.5-MHz Variable Bandwidth I-f Amplifier A3A3		
CR1 through CR4	1N251	Diode switches
Q1	2N3694	6.5-MHz amplifier
Q2	2N3015	Emitter follower
Q3	2N3015	Paraphase amplifier
Q4	2N3694	Emitter follower
Q5	2N3694	6.5-MHz amplifier
Q6	2N3694	Paraphase amplifier
Q7	2N3694	P/O Darlington emitter follower
Q8	2N3642	P/O Darlington emitter follower
6.5-MHz Logarithmic Amplifier A3A4		
CR1 through CR6	1N251	Video detectors
Q1	SE3002 (Fairchild)	6.5-MHz limiting amplifier
Q2 and Q3	2N3646	6.5-MHz limiting amplifiers
Q4	2N3694	Emitter follower
Q5 through Q7	2N3646	6.5-MHz limiting amplifiers
Q8	2N3568	P/O Complementary amplifier
Q9	2N3638	P/O Complementary amplifier
Linear/Power Amplifier A3A5		
CR1	FDH666 (Fairchild)	Video detector
CR2	1N749	Coupling diode
Q1	2N3641	6.5-MHz amplifier
Q2	2N3568	P/O Complementary amplifier
Q3	2N3638	P/O Complementary amplifier
Q4	2N3638	Emitter follower
Q5	U148 (Siliconics)	Square-law amplifier

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Linear/Power Amplifier A3A5 (Cont'd)		
Q6	2N3568	P/O Complementary amplifier
Q7	2N3638	P/O Complementary amplifier
Deflection Amplifiers A4		
Q1 and Q2	2N3694	Emitter-coupled difference amplifier
Q3	2N3638	Amplifier
Q4 and Q5	2N3694	Emitter-coupled difference amplifier
Q6	2N3638	Amplifier
Q7	2N3641	Constant current source
Q8 and Q9	2N3440	Vertical deflection amplifier
Q10	2N3641	Constant current source
Q11 and Q12	2N3440	Horizontal deflection amplifier
Sawtooth/Intensifier A5		
CR1 and CR2	FDH666 (Fairchild)	Clamps
CR3	FDH666 (Fairchild)	Switch
CR4	1N749	Voltage regulator
CR5 and CR6	FDH666 (Fairchild)	Clamps
Q2	2N3694	P/O Emitter-coupled difference amplifier
Q3	2N3641	P/O Emitter-coupled difference ampl.
Q4 and Q5	2N3646	Schmitt trigger
Q6	2N3638	Pulse amplifier
Q7	2N3641	P/O Emitter-coupled difference amplifier
Q8	2N3440	P/O Emitter-coupled difference ampl.
Q9	2N3440	Driver emitter follower
Q10	2N3646	Emitter follower

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Sawtooth/Intensifier A5 (Cont'd)		
Q11 and Q12	2N3646	Bistable multivibrator
Q13	2N3638	Biasing transistor
Q14	2N3638	P/O Discharge network
Q15	2N1480	P/O Discharge network
Q16	2N2945	Constant current source
Q17	2N3638	P/O Biasing network
Q18	2N3641	P/O Biasing network
Q19 through Q23	2N3646	NOR Gates
Q24 through Q26	2N3646	Inverters
Q27 and Q28	2N3646	NOR Gates
Q29	2N3646	P/O Darlington emitter follower
Q30	2N5306	P/O Darlington emitter follower
Q31 and Q32	2N3646	Schmitt trigger
Q33	2N3646	Inverter
Q34 and Q35	2N5306	Emitter-coupled Darlington difference amplifier
Q36 and Q37	2N3646	Schmitt trigger
Q38 and Q39	2N3646	Monostable multivibrator
Q40	2N3638	Timing switch
CRT Power Supply A6		
CR1	1N251	Discharge diode
CR2 and CR3	1N251	Back-bias protective diode
CR4 through CR9	EH-300 (Electronic Divices)	Voltage doublers
Q1 and Q2	2N4922	Oscillator
Q3	2N4870	Starting transistor

TABLE 1-2. ELECTRON TUBE, TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont'd)

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Rectifier/Filter A7		
CR1 and CR2	MV-10C (Solitron)	Full-wave rectifier
CR3 and CR4	1N4089	Full-wave rectifier
CR5 through CR8; CR9 through CR12	1N4089	Full-wave bridge rectifiers
Power Supply Control A8		
CR1 and CR2	1N4089	Short circuit protection
CR3	1N821	Voltage regulator
CR4 and CR5	1N4089	Short circuit protection
CR6	1N821	Voltage regulator
Q1	2N3440	Emitter follower
Q2	2N3440	D-c amplifier
Q3 and Q4	2N3440	Emitter-coupled difference amplifier
Q5	2N3638	Emitter follower
Q6 and Q7	2N3694	D-c amplifiers
Q8	2N3638	Emitter follower
Q9 and Q10	2N3694	D-c amplifiers
V1	Z82R (Signalite)	Voltage regulator
Auxiliary Control A9		
Q1	2N3641	P/O Emitter-coupled difference amplifier
Q2	2N3563	Constant current source
Q3 and Q4	2N3638	Darlington emitter follower
Q5 and Q6	2N3641	P/O Emitter-coupled difference amplifier
Q7 and Q8	2N3638	Darlington emitter follower
Q9	2N3563	Constant current source
Q10	2N3641	P/O Emitter-coupled difference amplifier

TABLE 1-3 FUSE COMPLEMENT

Reference Symbol Number	Type	Function
F1 and F2	1.25 ampere (delay)	Line protective fuses
A7F1	0.1 ampere (delay)	+100 volt supply protective fuse
A7F2	2 ampere (delay)	+12 volt supply protective fuse
A7F3	1.25 ampere (delay)	-12 volt supply protective fuse

SECTION II
OPERATION

2-1. GENERAL.

2-2. The procedures for proper operation of the Main Frame are dependent upon the associated Tuning Head that constitutes the spectrum analyzer system. The operating procedures for the particular system are therefore contained in the Operation section of the appropriate Tuning Head manual (volume which occupies the front half of this volume).

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The Main Frame, used in conjunction with an appropriate Tuning Head, displays the frequency-energy distribution of a signal or group of signals within the range of the tuning head. The Main Frame is basically a double-conversion superheterodyne receiver which is automatically and repetitively tuned through a portion of the frequency band (the portion is selected at the tuning head), with the output displayed as vertical deflections on a CRT screen. Because the horizontal sweep of the CRT is synchronized to the frequency of the swept local oscillator of the Main Frame, the vertical deflections are automatically positioned along the frequency-calibrated horizontal axis of the CRT screen.

3-3. SIMPLIFIED BLOCK DIAGRAM ANALYSIS.

3-4. The simplified block diagram, figure 3-1, shows the functional relationship of all circuits in the MF-100. All front panel controls, indicators, and connectors are included in the diagram.

3-5. The input signal from the tuning head, applied at the IF INPUT connector at the rear of the Main Frame, occupies the frequency band of 160 ± 50 MHz. This signal is applied through an input i-f attenuator that can be adjusted with the IF ATTENUATOR controls in 1 dB steps from 0 to 69 dB to prevent overloading the circuits of the Main Frame. The attenuated signal is applied to a 160 MHz amplifier where it is combined with the output of the marker generation circuits. The output of the marker generation circuits consists of a 160 MHz carrier (except when the MARKER MODULATION LEVEL control is rotated fully ccw to OFF) with or without modulation sidebands. The modulation may be produced by an internally generated 10 MHz signal, which produces sidebands at 10 MHz intervals, or by an internally generated 1 MHz signal, producing sidebands at 1 MHz intervals, or from an external source producing sidebands at any desired frequency spacing. The source of modulation is controlled by the MARKER MODULATION switch. The amplitude of the marker output is controlled by the MARKER MODULATION LEVEL control.

3-6. The output of the 160 MHz amplifier is applied through high-pass and low-pass filters to a mixer where it is mixed with the output of the swept local oscillator. The high- and low-pass filters prevent the generation of spurious responses, that would otherwise result from mixing extraneous outputs from the 160 MHz amplifier and harmonics of the swept local oscillator. The wideband swept local oscillator operates above the incoming i-f signal while the narrow band swept local oscillator operates below the incoming i-f signal. The selected local oscillator is swept above and below its center frequency (220 MHz or 100 MHz) by the sawtooth sweep input from the sawtooth generation circuits. The range over which the selected local oscillator is swept is determined by the setting of the FREQ DISPERSION switch and VARIABLE control; at maximum frequency dispersion, the wideband local oscillator is swept from 270 to 170 MHz, producing a frequency sweep of 100 MHz. At .3 MHz/DIV, which is the maximum dispersion for the narrow band local oscillator, the oscillator is swept from 101.5 to 98.5 MHz, producing a frequency sweep of 3 MHz. The center frequency of the selected local oscillator is adjusted by the SIGNAL FREQ POSITION controls. Because the local oscillator in the tuning head operates above the incoming signal, lower frequency inputs produce higher difference frequencies; by sweeping the swept local oscillator from its higher frequency to its lower frequency, the higher difference frequency inputs to the Main Frame produce 60 MHz outputs from the mixer earlier in the sweep so that the frequency scale on the CRT is read from left to right. A discrete frequency input such as a CW input or a marker input, combines with the swept local oscillator output to produce, for a finite time during the sweep, a continuously varying difference frequency that will pass through the 60 MHz i-f amplifiers (the difference frequency, during this finite time, will change continuously from one end of the i-f bandpass to the opposite end). The i-f output of the mixer is applied through a 60-MHz amplifier to two other 60-MHz amplifiers. One of these amplifiers provides the 60-MHz output at the rear panel of the Main Frame; this output has a bandwidth of 5 MHz. This broadband output permits the unit to be used as a standard receiver. The gain of the other i-f amplifier is continuously adjustable over a 20-dB range by the front panel IF GAIN control. This uncalibrated control sets the pip amplitude to a convenient height for relative amplitude measurements. The output of this 60-MHz amplifier is applied to a mixer where it is combined with the fixed frequency output of the 53.5-MHz crystal oscillator. The 6.5-MHz output of this mixer is applied to the first of two diode switches.

3-7. The diode switch is controlled by the bandwidth control circuits so that the 6.5 MHz signal is routed to the 6.5 MHz widéband amplifier when the BANDWIDTH switch is set at 1000 kHz, while in other positions, the diode switch applies the 6.5 MHz signal to the narrow-band filter and then to a variable bandwidth amplifier. The variable bandwidth amplifier is controlled by the bandwidth control

circuits to provide a bandwidth of 1, 3, 10, 30, or 100 kHz. When the BANDWIDTH control is set to VAR, the BANDWIDTH VARIABLE control provides uncalibrated continuous adjustment of the bandwidth between the limits of 1 and 100 kHz. The output of either the wideband amplifier or the variable bandwidth amplifier is selected by a second diode switch that is controlled in the same manner as the first diode switch. The output of the second diode switch is applied to the log amplifier. The log amplifier provides two outputs. One output is derived from a log shaping circuit within the log amplifier; this output is a video signal whose amplitude is proportional to the log of the input amplitude. The other output of the log amplifier is applied through a 6.5 MHz amplifier and a linear detector to both a linear amplifier and a square law amplifier whose output, proportional to the square of the input amplitude, represents the relative power of each of the displayed frequency components. The desired amplitude-adjusted signal is selected by the AMPLITUDE SCALE switch and applied through the video amplifier and vertical deflection amplifier to the vertical deflection plates of the CRT. Continuous control of the video filter is provided by the BANDWIDTH VARIABLE control in all positions of the BANDWIDTH switch, except in the 1000 kHz position; in this position, there is no video filtering. With the switch in the VAR position, the BANDWIDTH VARIABLE control simultaneously affects the video filtering and i-f bandwidth so that the video bandwidth is automatically tracked with the i-f bandwidth.

3-8. The sawtooth that produces the horizontal sweep on the CRT and simultaneously sweeps the swept local oscillator circuits is generated in the sawtooth generation circuitry. When the SWEEP switch is set to any of the MS/DIV positions, the sawtooth generation circuits are set for analyzer operation and the sawtooth generation circuits may be either synchronized or free-running. In addition, when the SWEEP/SYNC switch is set to EXT SWEEP, an external sweep input may be used in lieu of the internally generated sawtooth; this permits the spectrum analyzer to be controlled (programmed) from a remote source. When the SWEEP switch is set to any of the US/DIV positions, the sawtooth generation circuits are set for synchroscope operation. In addition to generating the sawtooth, the sawtooth generation circuits produce a blanking signal that blanks the CRT between successive traces. The blanking pulse from the sawtooth generation circuits is applied through the intensifier circuits to the control grid of the CRT. Video pulses from the video amplifier are also applied to the intensifier circuits and, when their amplitude exceeds the voltage established by the INTENSIFIER control, produce intensification on the CRT that is controlled by the BRIGHTNESS control.

3-9. DETAILED THEORY OF OPERATION

3-10. GENERAL. The detailed theory of operation, given in paragraphs 3-11 on, is subdivided into seven parts, in which the individual functions are described. These descritpions are based on the detailed block diagrams and simplified schematics contained in this section, and on the individual schematic diagrams, figures 5-1 through 5-20.

3-11. SIGNAL PATH. The i-f input from the tuning head occupies a frequency band centered about 160 MHz. This input signal, is applied to i-f attenuator assembly A1 (see figure 3-2). The input attenuator consists of resistive pi attenuators that can be inserted or bypassed, depending on the position of the IF ATTENUATOR switches. One of the switches selects attenuators that can insert 10 through 60 dB of attenuation in 10-dB steps; the second switch selects attenuators that can introduce 1 through 9 dB of attenuation in 1-dB steps. Thus, the two switches combine to provide an attenuation range from 0 through 69 dB in 1-dB steps.

3-12. The attenuated i-f signal is applied to 160-MHz wideband amplifier board A2A3, which is mounted in front i-f assembly A2. The applied signal and the output of the marker generation circuits (refer to paragraph 3-20) are applied to the input of 160-MHz amplifier A2A3Q1. The output of amplifier A2A3Q1 is applied to negative feedback amplifier A2A3Q2 and, because the negative feedback is applied through a parallel-tuned circuit less degeneration and therefore higher gain are obtained at the higher frequencies, for they are closer to the frequency to which the tuned circuit is adjusted. This frequency-sensitive degenerative feedback compensates for the reduced high-frequency gain of the amplifier, resulting in a flat response over the range of 160 ± 50 MHz. The output of amplifier A2A3Q2 is applied through another negative feedback amplifier A2A3Q3. The output of A2A3Q3 is applied through emitter follower A2A3Q4 to A2A4, which contains a 60 MHz trap (L2, C3, and C4) that prevents an input 60 MHz signal from being applied to the balanced mixer and 60 MHz i-f amplifier; such a signal would otherwise appear as a baseline rise. A2A4 also contains an equalizer (R4, R5, and R6, C1, and L1) that introduces 1 db less attenuation at 210 MHz than at 110 MHz to further compensate for reduced high-frequency response elsewhere in the signal path. The output of A2A4 is applied to two cascaded filters A2A5 and A2A6. These filters provide sharp cutoff at the upper limit of the bandpass of the i-f. Thus these filters define the i-f bandwidth, and prevent any extraneous signals from being applied to the balanced mixer A2A7CR1-CR4.

3-13. The swept local oscillators operate at center frequencies of 220 MHz (WB) and 100 MHz (NB), which are 60 MHz above and below, respectively, the center of the frequencies applied to the input of balanced mixer A2A7CR1-CR4. At the start of each sweep, the local oscillator frequency is above its center frequency; at this time the carrier frequency to which the tuning head is tuned will produce a difference frequency from the balanced mixer that is above the bandpass of the 60 MHz amplifiers. As the sweep input varies, the difference frequency will also vary; at the end of the sweep, the difference from the balanced mixer will be below the bandpass of the 60 MHz amplifiers. For a small but finite time during the sweep, the difference frequencies that are produced are within the bandpass of the 60 MHz

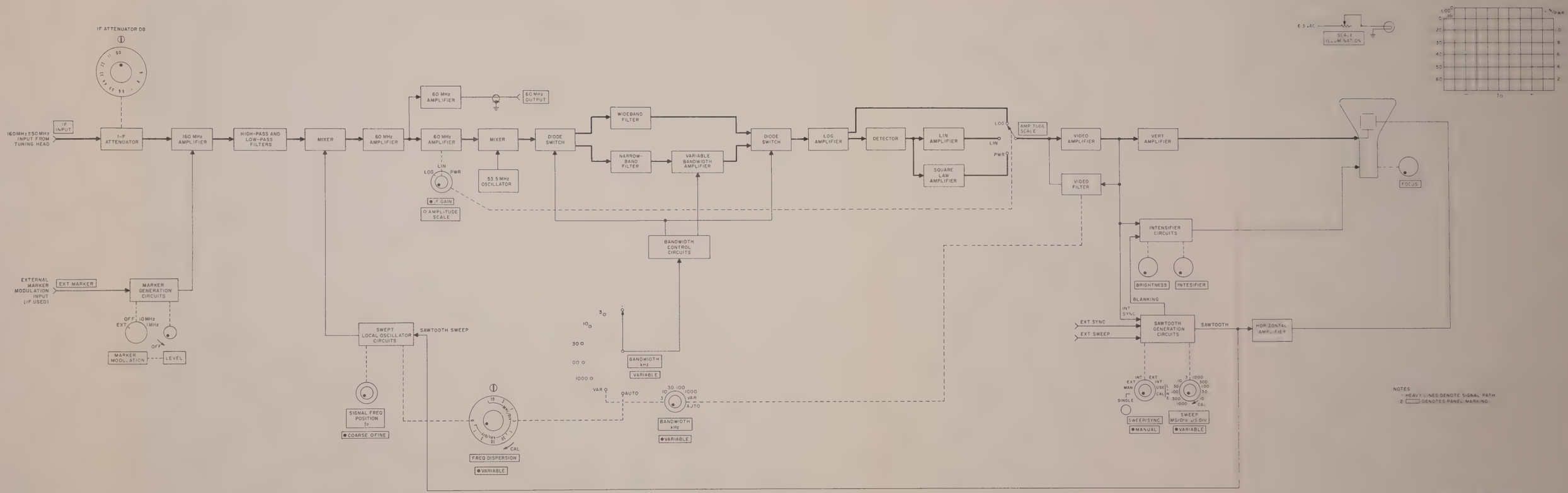
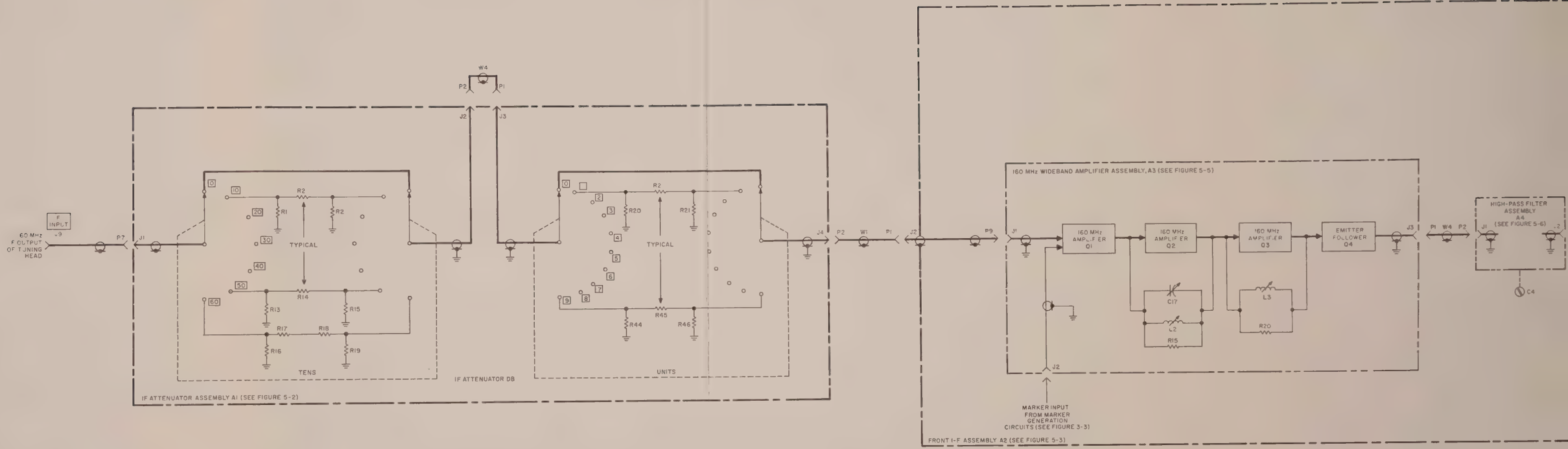


Figure 3-1. Main Frame, Simplified Block Diagram


W4
P2
P1
J2
J3
IF INPUT
60 MHz IF OUTPUT OF TUNING HEAD
J3
P7
J1
10
20
30
40
50
60
R2
R1
R2
TYPICAL
R14
R13
R15
R17
R18
R16
R19
TENS
0
2
3
4
5
6
7
8
9
R2
R20
R21
TYPICAL
R45
R44
R46
UNITS
IF ATTENUATOR DB
IF ATTENUATOR ASSEMBLY A1 (SEE FIGURE 5-2)
J4
P2
W1
P1
J2
P9
160 MHz WIDEBAND AMPLIFIER ASSEMBLY, A3 (SEE FIGURE 5-5)
J1
160 MHz AMPLIFIER Q1
160 MHz AMPLIFIER Q2
160 MHz AMPLIFIER Q3
EMITTER FOLLOWER Q4
J3
C17
L2
R15
L3
R20
J2
MARKER INPUT FROM MARKER GENERATION CIRCUITS (SEE FIGURE 3-3)
FRONT I-F ASSEMBLY A2 (SEE FIGURE 5-3)
P1
W4
P2
HIGH-PASS FILTER ASSEMBLY A4 (SEE FIGURE 5-6)
J1
J2
C4

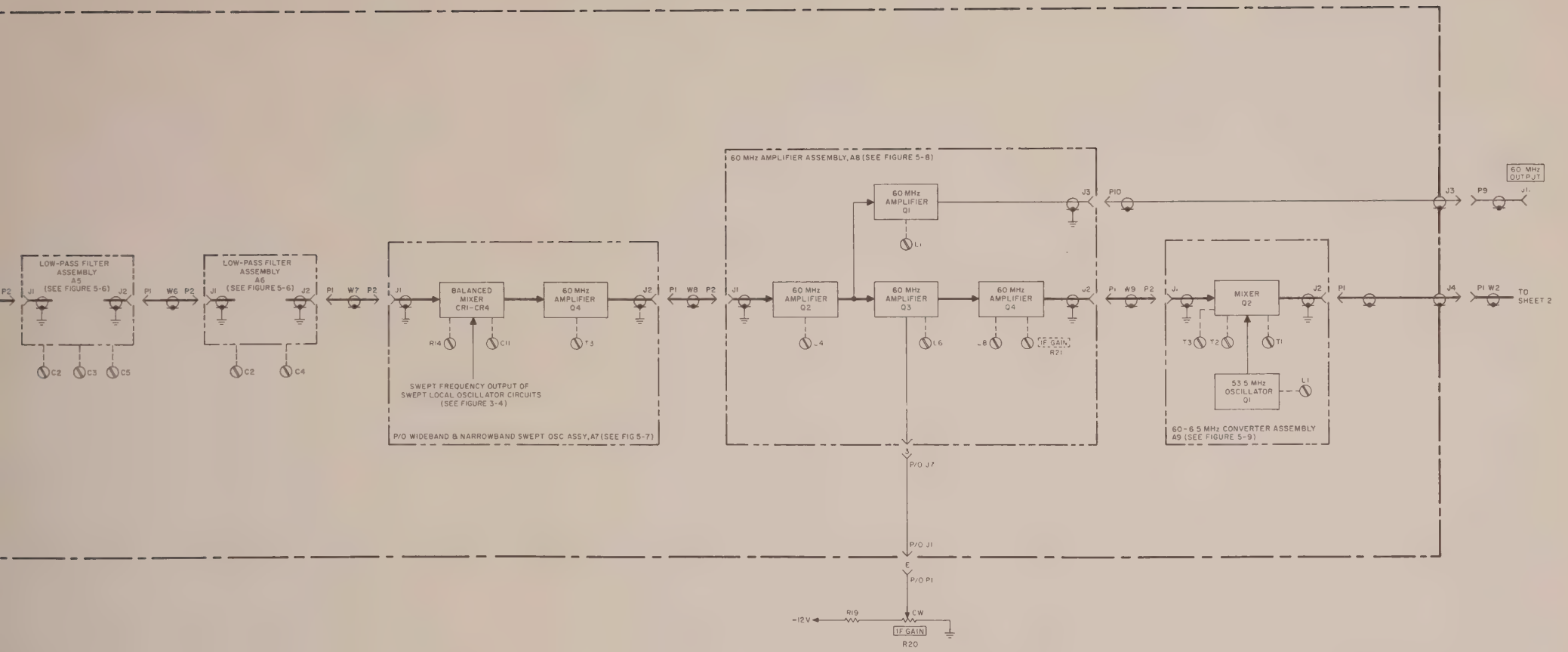
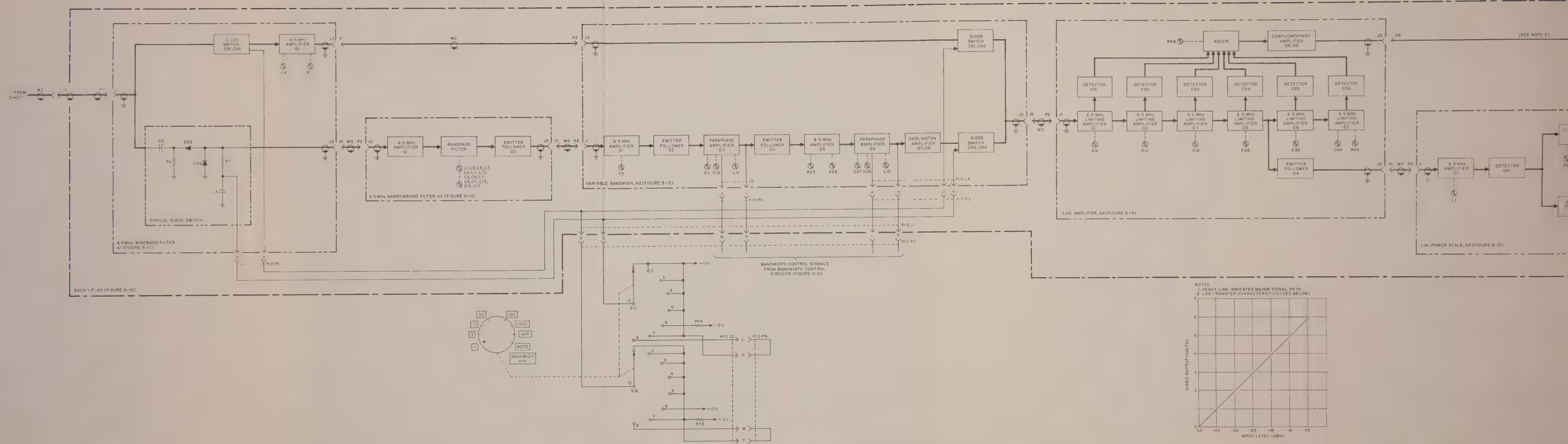


Figure 3-2. Main Frame, Detailed Block Diagram (Sheet 1 of 2)


FROM SHEET
DIODE SWITCH CR1, CR2
6.5 MHz AMPLIFIER Q1
C9
R
C2
CR3
R5
CR4
R7
.4
TYPICAL DIODE SWITCH
6.5 MHz WIDEBAND FILTER A1 (FIGURE 5-11)
P/O P1
BACK I-F, A3 (FIGURE 5-10)
6.5 MHz AMPLIFIER Q1
BANDPASS FILTER
L1,L3,L5,L7, L9,L11,L13, C3,C5,C7, C9,C11,C13, C15,C17
EMITTER FOLLOWER Q2
6.5 MHz NARROWBAND FILTER, A2 (FIGURE 5-12)
6.5 MHz AMPLIFIER Q1
C5
EMITTER FOLLOWER Q2
PARAPHASE AMPLIFIER Q3
C11 C13
L5
EMITTER FOLLOWER Q4
6.5 MHz AMPLIFIER Q5
R25
C23
PARAPHASE AMPLIFIER Q6
C27 C29
L12
DARLINGTON AMPLIFIER Q7,Q8
DIODE SWITCH CR3, CR4
VARIABLE BANDWIDH, A3 (FIGURE 5-13)
P/O P6
P/O P5
P/O J1
P/O P7
BANDWIDTH CONTROL SIGNALS FROM BANDWIDTH CONTROL CIRCUITS (FIGURE 3-5)
30
100
0
1000
3
VAR
1
AUTO
BANDWIDH KHZ
S1C
S1B
+12V
R54
-12V
P/O J2
P/O P9
+12V
-2V
R53
R46
ADDER
COMPLEMENTARY AMPLIFIER Q8,Q9
DETECTOR CR1
DETECTOR CR2
DETECTOR CR3
DETECTOR CR4
DETECTOR CR5
DETECTOR CR6
6.5 MHz LIMITING AMPLIFIER Q1
6.5 MHz LIMITING AMPLIFIER Q2
6.5 MHz LIMITING AMPLIFIER Q3
6.5 MHz LIMITING AMPLIFIER Q5
6.5 MHz LIMITING AMPLIFIER Q6
6.5 MHz LIMITING AMPLIFIER Q7
C6
C12
C16
C26
C36
C44
R44
EMITTER FOLLOWER Q4
LOG AMPLIFIER, A4 (FIGURE 5-14)
(SEE NOTE 2)
6.5 MHz AMPLIFIER Q1
C2
DETECTOR CR1
LIN-POWER SCALE, A5 (FIGURE 5-15)
NOTES
1. HEAVY LINE INDICATES MAJOR SIGNAL PATH
2. LOG TRANSFER CHARACTERISTICS (SEE BELOW)
VIDEO OUTPUT (VOLTS)
INPUT LEVEL (dBm)
-55
-45
-35
-25
-15
-5
+5

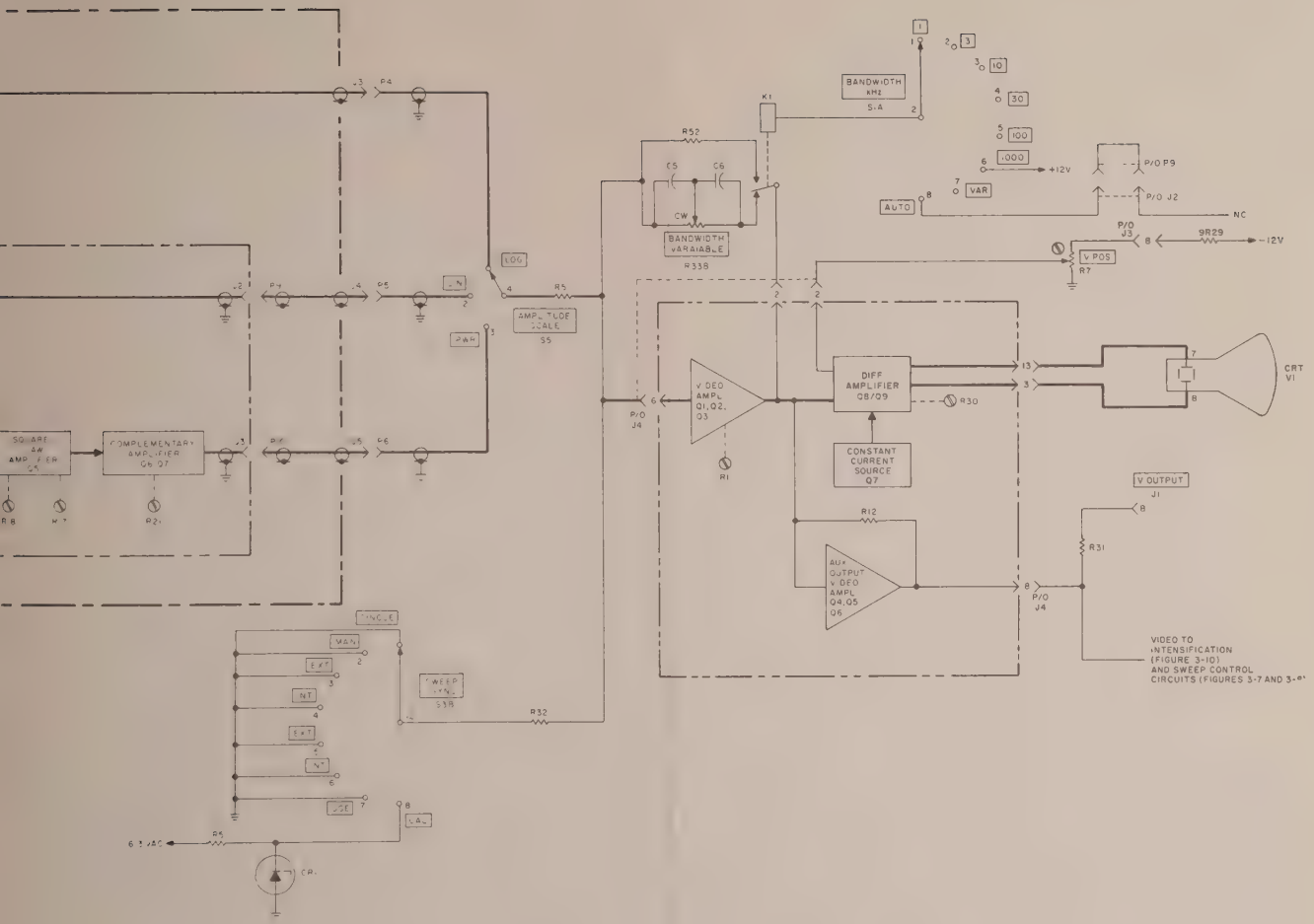


Figure 3-2. Main Frame, Detailed Block Diagram (Sheet 2 of 2)

amplifier. A separate, very stable oscillator is used as the narrow band swept local oscillator to restrict unwanted incidental FM (displacement (jitter) of frequency components on successive sweeps) due to oscillator instability. This effect is most noticeable on the lowest dispersion displays. A separate, less stable, oscillator is used as the wideband swept local oscillator to sweep over a wider range; slight instability is not noticeable at these dispersions. Both the oscillators and their sweep inputs are discussed in paragraphs 3-22 through 3-26. Potentiometer A2A7R14 primarily balances the local oscillator input to the balanced mixer, while capacitor A2A7C11 tunes the balanced mixer output to 60 MHz. However, interaction does occur and both controls are used to balance the mixer.

3-14. The output of the balanced mixer is applied through 60 MHz amplifier A2A7Q4 to 60 MHz amplifier A2A8Q2. The output of this amplifier is applied both to 60 MHz amplifier A2A8Q1 and to 60 MHz amplifier A2A8Q3. The output of A2A8Q1 which has a bandwidth of 5 MHz is applied to the 60 MHz OUTPUT connector J11 on the rear of the Main Frame. This output, when connected to appropriate detection equipment, allows the analyzers to serve as a receiver. The gain of 60 MHz amplifier A2A8Q3 is adjusted by the front panel IF GAIN control, which adjusts the negative base bias applied to this stage. The output of this amplifier is applied to 60 MHz amplifier A2A8Q4, whose gain is adjusted by internal adjustment A2A8R21; R21 is connected in series with the emitter bypass capacitor, and thereby controls degeneration. The output of A2A8Q4 is applied to mixer A2A9Q2 where it is mixed with the output of crystal oscillator A2A9Q1. The output of the mixer is at 6.5 MHz.

3-15. This 6.5 MHz output is applied to two diode switches located in 6.5 MHz WB filter A3A1 in the back i-f assembly A3. One diode switch passes the 6.5 MHz signal to 6.5 MHz amplifier A3A1Q1 when wideband i-f operation is selected, and the other diode switch passes the signal to 6.5 MHz amplifier A3A2Q1 at all other times. Each diode switch is controlled by the application of +12 or -12 volts from the BANDWIDTH switch. When -12 volts is applied to any diode switch, the series diode (such as A3A1CR3) is back-biased while the shunt diode (A3A1CR4) is shorted; under these conditions the diode switch does not pass the signal. When +12 volts is applied, the series diode is forward-biased while the shunt diode is back-biased, and the signal passes through the diode switch. Note that when the narrowband diode switches receive +12 volts, the wideband diode switches receive -12 volts.

3-16. The wideband 6.5 MHz amplifier has a 1 MHz bandwidth, while the narrow band 6.5 MHz amplifiers can be varied between 1 and 100 kHz. The gain of the amplifiers in the wideband and narrow band signal paths is separately adjustable, so that the noise level is displayed at the same amplitude in either 100 kHz or 1000 kHz bandwidth. The gain of wideband amplifier A3A1Q1 is adjusted by A3A1R11 which is the unbypassed portion of the emitter resistance. The output of A3A1Q1 is applied to a second diode switch A3A3CR1-CR4 which is controlled by the same control voltages as the first diode switch; when the first diode switch applies the 6.5 MHz signal to A3A1Q1 the second diode switch passes the output of A3A1Q1. When narrow band i-f operation is selected by the front panel BANDWIDTH switch, the output of the first diode switch is applied to A3A2Q1, which drives a sharp bandpass filter. This filter eliminates the spurious responses of the crystals in the variable bandwidth amplifier. The output of the bandpass filter is applied through emitter follower A3A2Q2 to the variable bandwidth i-f amplifier on board A3A3. The bandwidth of this amplifier is controlled continuously or in steps by dc voltages from the bandwidth control circuits (paragraph 3-27), which varies the impedance of the tuned circuit in this amplifier. The output of the paraphase amplifier is coupled from the emitter through a 6.5 MHz crystal, which is utilized in its series-resonant mode. The crystal is loaded by a paralled-tuned circuit consisting of a capacitor and A3A3L5, whose impedance determines the bandpass of the crystal (refer to paragraph 3-28). The crystal which passes the 6.5 MHz signal through the equivalent series-resonant circuit, also passes signals through its shunt capacitance. An out-of-phase signal is taken from the collector of A3A3Q3 to cancel that signal. This neutralizing signal is adjusted by capacitor A3A3C13. Capacitor A3A3C11 adjusts the phase of the signal passed through the crystal shunt capacitance so that A3A3C13 can better neutralize this signal. After processing in paraphase amplifier A3A3Q3, the signal is coupled through emitter follower A3A3Q4 and tuned amplifier A3A3Q5 to paraphase amplifier A3A3Q6, which is identical to A3A3Q3 and further controls the bandwidth. The gain of A3A3Q5 is adjusted by A3A3R25, which is a portion of the unbypassed emitter resistance of 6.5 MHz amplifier A3A3Q5. The output of the variable bandwidth amplifier is applied through diode switch A3A3CR1-CR4 to the log amplifier A3A4.

3-17. The 6.5 MHz signal from the second diode switch is applied to 6.5 MHz logarithmic i-f amplifier A3A4. This type of circuit is called successive detection. The signal is coupled to A3A4Q1, the first stage of a six-stage sequentially-limiting i-f amplifier chain. The output of each stage is applied to a diode detector A3A4CR1 through CR6, which feeds a resistive adder A3A4R8, R15, R22, R29, R40, and R47, which incorporates a delay line A3A4C7, L4, C15, L7, etc. that delays the outputs of the first stages more than those of the later ones to compensate for the inherent delay of the six-stage amplifier; thus all contributions to be added are in synchronism. Each of the six stages is identical, having the same gain and the same saturation level. As the applied signal increases above the noise the output of A3A4Q7 exceeds the threshold level of A3A3CR6, and the detector applies a voltage proportional to the input to the adder. As the signal continues to increase, the output of A3A4Q7 also increases until it reaches saturation, thereby limiting its contribution to the adder. As A3A4Q7 reaches its saturation point, the output of A3A4Q6 is of sufficient amplitude to overcome the threshold voltage of A3A4CR5, causing the diode detector to contribute to the adder. This

sequential limiting of amplification from the higher level stages and contribution of video from the lower level ones continues until the applied signal drives A3A4Q1 into saturation. Thus each successive increase of 10 db (for example) in input level produces an equal (linear) increase in output voltage. (See transfer characteristics on figure 3-2.) The adder applies the sum of the positive video contributions from detectors A3A4CR1 through CR6 to complementary amplifier A3A4Q8, Q9. The input to A3A4Q8 is adjusted by A3A4R48 so that the maximum input (sum of all contributions) corresponds to 0 dB on the LOG scale. The gain of A3A4Q7 is adjusted by A3A4R44 so that the minimum signal that produces a contribution is 60 dB below the signal level that produces saturation in A3A4Q1; thus an on-screen dynamic range of 60 dB is achieved. The complementary amplifier provides a low impedance source for driving the video amplifier (paragraph 3-19).

3-18. The output of 6.5 MHz amplifier A3A4Q5 is applied through emitter follower A3A4Q4 to the lin-power scale board A3A5. The output of A3A4Q5 is directly proportional to the input signal level until A3A4Q5 approaches saturation. The output of emitter follower A3A4Q4 is amplified by 6.5 MHz amplifier A3A5Q1 and detected by diode A3A5CR1. The detected output of A3A5CR1 is applied to complementary amplifier A3A5Q2, Q3. The complementary amplifier provides the output for the linear display on the CRT. The amplitude of the signal applied to the complementary amplifier is adjusted by screwdriver control A3A5R8. The dc voltage at the output of the complementary amplifier, which is dc coupled through the remaining circuits to the CRT, is adjusted by screwdriver adjustment A3A5R11, so that with no signal input, the CRT trace is at the baseline. The detected output of A3A5CR1 is also applied to emitter follower A3A5Q4 whose output is coupled through a Zener diode to square-law amplifier A3A5Q5. The Zener diode provides dc offset with no loss in signal amplitude. The square-law amplifier utilizes the non-linear characteristics of a field-effect transistor (FET). The gain of the square-law amplifier is established by adjusting the load resistor A3A5R18. The linearity (square-law transfer characteristic) of the amplifier is controlled by adjusting A3A5R17, thereby setting the dc gate voltage of amplifier A3A5Q5. The output of the square-law amplifier is applied through complementary amplifier A3A5Q6, Q7 whose output is dc coupled through the remaining circuits to the CRT. Baseline adjustment A3A5R21 serves the same purpose for this complementary amplifier as A3A5R11 serves for complementary amplifier A3A5Q2, Q3.

3-19. The AMPLITUDE SCALE switch selects the logarithmic output of complementary amplifier A3A4Q8, Q9, the linear output of complementary amplifier A3A5Q2, Q3, or the power output of complementary amplifier A3A5Q6, Q7. The selected output is supplied through resistor R51 to the summing junction of video amplifier A4Q1, Q2, Q3. When the SWEEP/SYNC switch S3B is set to CAL, clipped half-wave signal derived from the 6.3 vac output of the power transformer is applied through resistor R32 to the summing junction. The video amplifier consists of a difference amplifier A4Q1, Q2 and inverting amplifier A4Q3. The difference amplifier contains DC BAL adjustment A4R1, which sets the output of the amplifier to 0 VDC when no inputs are applied. In all positions of the BANDWIDTH switch except the 1000 kHz position, relay K1 is deenergized and the feedback for the video amplifier consists of the BANDWIDTH VARIABLE control R33B, which is shunted by capacitor C5 when the control is fully CCW and by C6 when the control is fully CW. The dc gain of the video amplifier is determined by the total resistance of R33B; the gain of higher frequencies depends upon the total capacitive feedback, which depends upon the setting of the BANDWIDTH VARIABLE control. When the BANDWIDTH switch is set to 1000 kHz, relay K1 is energized and the network consisting of C5, C6, and R33B is replaced by a single resistor R52, which is the same ohmic value as R33B. Thus the dc gain of the amplifier is not affected, and the video bandwidth is limited only by the amplifier. The output of the video amplifier is applied both to difference amplifier A4Q8/Q9 and to auxiliary output amplifier A4Q4, Q5, Q6. The other input to the difference amplifier is a dc voltage derived from the front panel V POS screwdriver adjustment R7. This voltage determines the dc component of the amplifier output; therefore adjusting this dc voltage shifts the display up or down without changing its amplitude. The total current through the two transistors of the differential amplifier is maintained constant by A4Q7 whose base voltage is determined by a fixed voltage divider; A4R30 adjusts the gain of the differential amplifier to provide the desired output to the CRT. The output of the auxiliary output amplifier is applied both to the V output pin J1-B, which can be used for remote operation and for X-Y plotting, and to the sawtooth trigger and intensification circuits (paragraphs 3-29 and 3-49, respectively).

3-20. MARKER GENERATION CIRCUITS. The marker generation controls can be adjusted to provide no markers, only a center frequency marker, or a center frequency marker with sidebands located at 1-MHz or 10-MHz intervals or at intervals controlled by an external modulation input. Figure 3-3 is the detailed block diagram of the marker modulation circuits. When the MARKER MODULATION LEVEL control R21 is not set to its CCW limit, switch S8, which is ganged to the MARKER MODULATION LEVEL control, applies -12 volts to the 160-MHz marker oscillator A2A1Q1 and to amplifier A2A1Q2. (See figure 3-3.) When the MARKER MODULATION switch S4 is set to OFF, the output of the 160-MHz marker oscillator is applied to balanced modulator A2A1CR1 through CR4, whose output is the incompletely suppressed oscillator (carrier) input. When S4 is set at 10 MHz, -12 volts is applied to the 10-MHz marker oscillator A2A1Q3. The output of this oscillator is applied through amplifier A2A1Q2, which serves as a buffer that applies the 10-MHz signal to the balanced modulator. The output of the modulator contains the incompletely suppressed carrier and sidebands spaced at 10 MHz intervals from the carrier.

3-21. When the MARKER MODULATION switch is set to 1 MHz, -12 volts is applied to 1-MHz marker

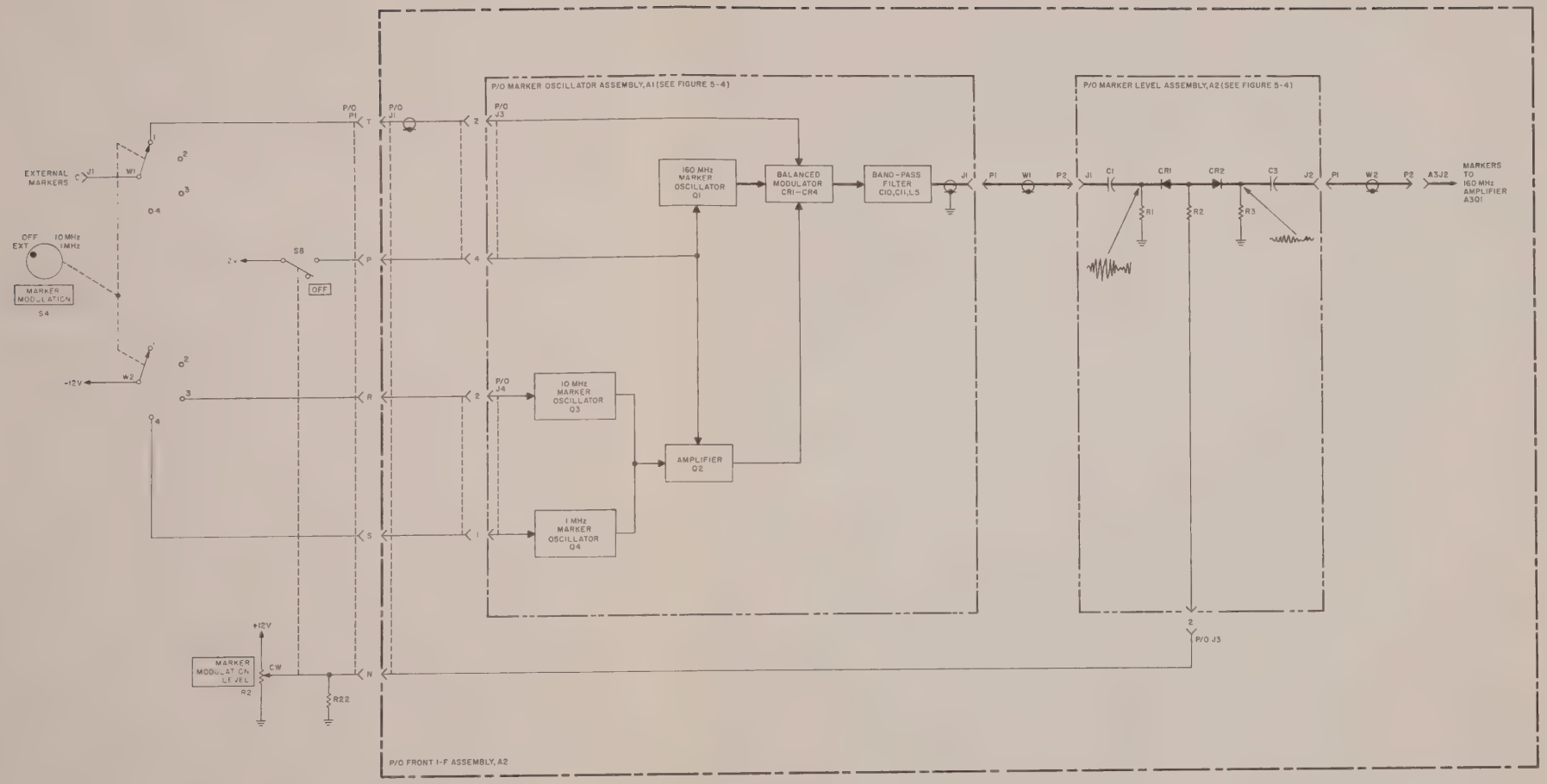


Figure 3-3. Marker Generation Circuitry, Detailed Block Diagram

oscillator A2A1Q4, and the 160-MHz carrier is then modulated by 1MHz. When the MARKER MODULATION switch is set to EXT, an external marker input, applied at pin C of connector J1, is applied directly to the balanced modulator. The modulator output is applied through bandpass filter consisting of A2A1C10, C11, and L5, which removes those frequencies that would otherwise mix with outputs of the swept local oscillators to produce spurious responses. The output of the bandpass filter is applied to marker level board A2A2. The MARKER MODULATION LEVEL control R21 establishes the forward bias on diodes A2A2CR1 and A2A2CR2, which, with A2A2R2, comprise a T-attenuator. As the forward bias increases, the impedance of the diodes decreases, and the marker output increases. The output of the marker level board is applied to the 160 MHz amplifier A3A1.

3-22. SWEPT LOCAL OSCILLATOR CIRCUITS. The swept local oscillator circuits provide the frequency to the mixer that is swept in synchronism with the CRT trace to provide the amplitude-versus-frequency display. Figure 3-4 is the detailed block diagram of the swept local oscillator circuits. The swept local oscillator circuits contain wideband local oscillator A2A2Q3 and narrow band local oscillator A2A2Q5. When FREQ DISPERSION switch S6 is set to any of the three widest-dispersion positions, +12 volts is applied through the switch contacts to the wideband local oscillator, which provides the swept local oscillator signal in these switch positions. In the remaing positions of the FREQ DISPERSION switch, +12 volts is applied to the narrow-band local oscillator, which provides the swept local oscillator signal in these switch positions. The selected local oscillator is swept by a sawtooth voltage and the resultant center frequency is determined by an applied dc voltage.

3-23. The dc voltage for the wideband local oscillator is adjusted by the front panel SIGNAL FREQ POSITION f_0 COARSE and FINE controls R1A and R1B in series with screwdriver adjustments A9R20 and A9R21, respectively, and then it is applied to adder A2A7Q1. The dc voltage for the narrow-band local oscillator is controlled in the same manner, even though it is picked off from a different point in the circuit, and then applied to adder A2A7Q7.

3-24. The amplitude of the sawtooth voltage applied to the local oscillator is selected by FREQ DISPERSION switch S6 either from the voltage divider network consisting of resistors R37/R38/R39 (wideband) or R40 -- R45 (narrow band). This voltage can be adjusted by rotating FREQ DISPERSION VARIABLE control R36 counterclockwise from its CAL position. In addition, the sawtooth amplitude can be adjusted separately for each local oscillator to calibrate the various positions of the FREQ DISPERSION switch; for wideband, the sawtooth is adjusted by WB DISP screwdriver adjustment A9R17, and for narrow band by NB DISP adjustment A9R18. These sawtooth voltages are applied to adders A2A7Q1 and A2A7Q7 to combine the frequency dispersion sawtooth voltage with the signal frequency position dc voltage. When the FREQ DISPERSION switch is set at 0 (for example in synchroscope operation), the narrow-band local oscillator is energized, but no sawtooth voltage is applied. The dc voltage that is applied controls the fixed frequency at which the narrow-band local oscillator operates in this switch position.

3-25. The output of each adder, which is the sum of the dc and sawtooth inputs, is applied to a shaping amplifier A2A7Q2 or A2A7Q6. Because the local oscillators are non-linear and a linear sweep presentation is desired, the sawtooth that is applied to each shaping amplifier is reshaped to a curve that compensates for the nonlinear frequency-voltage characteristic of its associated local oscillator. Reshaping in shaping amplifier A2A7Q2 is accomplished by varistor A2A7RV1, whose resistance varies as the applied voltage changes. The overall linearity of the local oscillator output is adjusted by screwdriver adjustment A2A7R9 (wideband) and A2A7R25 (narrow band).

3-26. The wideband local oscillator A2A7Q3 is a modified Colpitts circuit in which the tuning is adjusted continuously by the current through current-controlled inductor A2A7L4. The inductance of A2A7L4 decreases as its current increases; thus the low voltage end of the sawtooth, which results in increased current through L4, produces the high-frequency limit of the local oscillator sweep. The narrow-band local oscillator is a modified Hartley circuit, which contains varactor C20, whose capacitance is a function of the instantaneous voltage applied. The output of the local oscillator that is operating is applied to the balanced mixer A2A7CR1-CR4.

3-27. BANDWIDTH CONTROL CIRCUITS. The bandwidth control circuits provide dc voltages that control the bandwidth of the 6.5 MHz variable bandwidth amplifier. Figure 3-5 is the detailed block diagram for the band-width control circuits.

3-28. The bandwidth of the 6.5 MHz variable bandwidth amplifier is controlled by the intensity of two lamps whose light outputs are played upon light-sensitive resistors; within the variable bandwidth amplifier, the bandwidth of the tuned circuits varies with these resistance values. An increase in resistance results in an increase of the bandwidth. The lamp intensity is controlled by two identical bridge circuits, each consisting of two base-bias resistance networks and a high gain difference amplifier in series with a Darlington emitter follower. Because the two control circuits are identical, only one will be discussed here. The position of BANDWIDTH switch S1D selects a resistor or combination of resistors from R46 through R49 or BANDWIDTH VARIABLE potentiometer R33A which, in series with R56 to ground, represent the control leg of the bridge. These resistors, in series with resistor A9R11 and -12V, form a voltage divider to provide base-bias for transistor A9Q5 (1/2 of the differential amplifier A9Q5/21). Base-bias for transistor A9Q1, the other half of the amplifier, is provided by the voltage divider consisting of potentiometer A9R4A to -12V, resistor A9R1 and the unknown leg of the bridge A3A3R17, which has its ground return through

A3A3L5. Changes in the setting of switch S1 (or rotation of the BANDWIDTH VARIABLE potentiometer R33A when switch S1 is set to position 7) will unbalance the bridge, causing a differential voltage between the two inputs of the differential amplifier. This differential voltage is amplified and applied to the lamp of A3A3R17, causing the light sensitive resistor to change value in such a manner as to rebalance the bridge. The variation of the light-sensitive resistance therefore is directly proportional to the change of the resistance in the control leg of the bridge. When switch S1D is set to increase the total series resistance of the control leg of the bridge, less negative voltage is developed across resistor A9R11 and the base-bias of A9Q5 becomes more negative. The amplifier output, applied to the Darlington emitter follower becomes more positive and, therefore, a smaller voltage is developed across the lamp associated with the light sensitive resistor A3A3R17. The intensity of the lamp decreases, causing the resistance of the resistor to increase. When switch S1 is set to maximum resistance, the difference amplifier is actually back-biased; the resistance of the resistor becomes very high, looking like an open circuit, and the resistance of the circuit itself determines the bandwidth. Potentiometer R4 is set to calibrate the BANDWIDTH switch.

3-29. SAWTOOTH GENERATION CIRCUITS.

3-30. General. Functionally, two circuits are employed for sawtooth generation which are not mutually exclusive: one circuit, the sweep control circuit, provides the sweep gate necessary for sawtooth generation, and a blanking gate for use in the intensification circuits; the second, a sweep generation circuit, produces the sawtooth voltage that sweeps the swept local oscillators and CRT beam. Together, these circuits form an interdependent feedback loop. The sawtooth voltage of the sawtooth generation circuit, gated by the sweep control circuit is fed back to the sweep control circuit, primarily, so that it can end the sweep gate when full-scale sweep deflection potential has been reached. Blanking takes place at this time in preparation for the next sweep.

3-31. Sweep Control Circuit. The sweep control circuit generates sweep gate and blanking pulses by alternately setting and resetting a sweep gate flip flop. The "set" state of the flip flop describes a 1 output (+12V, nominal) for the sweep gate, and a 0 output (+6V, nominal) for the blanking output. The "reset" state is just the opposite - the sweep gate output is at the 0 level while the blanking output is at the 1 level. When the flip flop is set, the sawtooth waveform of the sweep generation circuit is enabled by the 1 output from the sweep gate side of the flip flop; and, when the flip flop is reset, the CRT blanking pulse is obtained from the 1 output of the blanking side. The blanking pulse is always generated during retrace, and, whenever the beam would be stationary (if not blanked) awaiting a retrace-initiating sync pulse, under sync control in the analyzer mode.

3-32. Because retrace occurs when the output of the sweep gate flip flop changes from the set to reset state, and the blanking pulse is available only when the flip flop is in the reset state, a conflict would occur during sync operation in the analyzer mode when the blanking pulse must be generated before retrace; but, a unique flip flop is used to solve this problem.

3-33. The sweep gate flip flop is unlike most flip flops, for if both transistors receive 0 base inputs, both transistors can be cut off simultaneously; and, consequently, both outputs are true until the sweep gate is terminated by an incoming retrace generating sync pulse. In free-running operation, the flip flop changes state like any other flip flop at the end of each sweep; retrace occurs and then the flip flop changes state again to initiate a new sweep.

3-34. Biasing transistor A5Q13 (shown in figure 3-6) maintains a positive potential at the emitters of flip flop transistors A5Q11 and A5Q12 of +6V. And as a result, 1 signal inputs applied to the base of either flip flop transistor have no effect.

3-35. If the input from the flip flop driver is at the 1 state, the collector-to-base cross coupling determines the state of that transistor; if the input is a 0, however, the crosscoupling has no effect. Therefore, when 0 inputs are applied to both transistors, they can be cut off simultaneously, producing the desired similar 1 outputs.

If both inputs are at the 1 state, the flip flop remains in the state which it has previously assumed.

3-36. The sweep control circuit utilizes NOR gates (figure 3-7) as the basic logic element. Each gate employs an NPN transistor biased below cutoff by a -12-volt base supply. When 0 inputs are applied to all of the NOR gate input leads, the net base potential is negative, the transistor is cut off, and a 1 is present at the output. When a 1 is applied to any of the input terminals the base becomes positive - coupling resistors isolate all other 0 inputs - and the transistor turns on. The output drops to ground potential (nominally), and a 0 is present at the output.

3-37. Figure 3-8 shows the sweep control circuit for both analyzer and synchroscope modes of operation. The analyzer mode is discussed first. SWEEP time switch S2 is set to any of the analyzer positions (MS/DIV) and SWEEP/SYNC switch S3 is set to INT SWEEP (black). Because of the interdependency of the sweep generation circuit and the sweep control circuit, logic diagram analysis of the control circuit begins at an arbitrary point in the recurring sequence that constitutes a sweep cycle; sweep gate flip flop A5Q12/A5Q11 is set and a sawtooth is being generated in the sweep generation circuit. (A 1 output is provided by A5Q12 and a 0 output is provided by A5Q11.) When the sawtooth becomes sufficiently positive, the sweep input from A5Q30 trips Schmitt Trigger A5Q31/A5Q32 which produces a 1 output that is inverted by A5Q33. The Schmitt trigger output, representing full-scale deflection of the sweep is used to generate a blanking pulse concurrent with retrace. The output from A5Q33 is inverted in the NOR gate A5Q21 because a 0 output is also coupled through A5Q26 from +12 volt potential on the wiper arm of SWEEP switch S2B. The 1

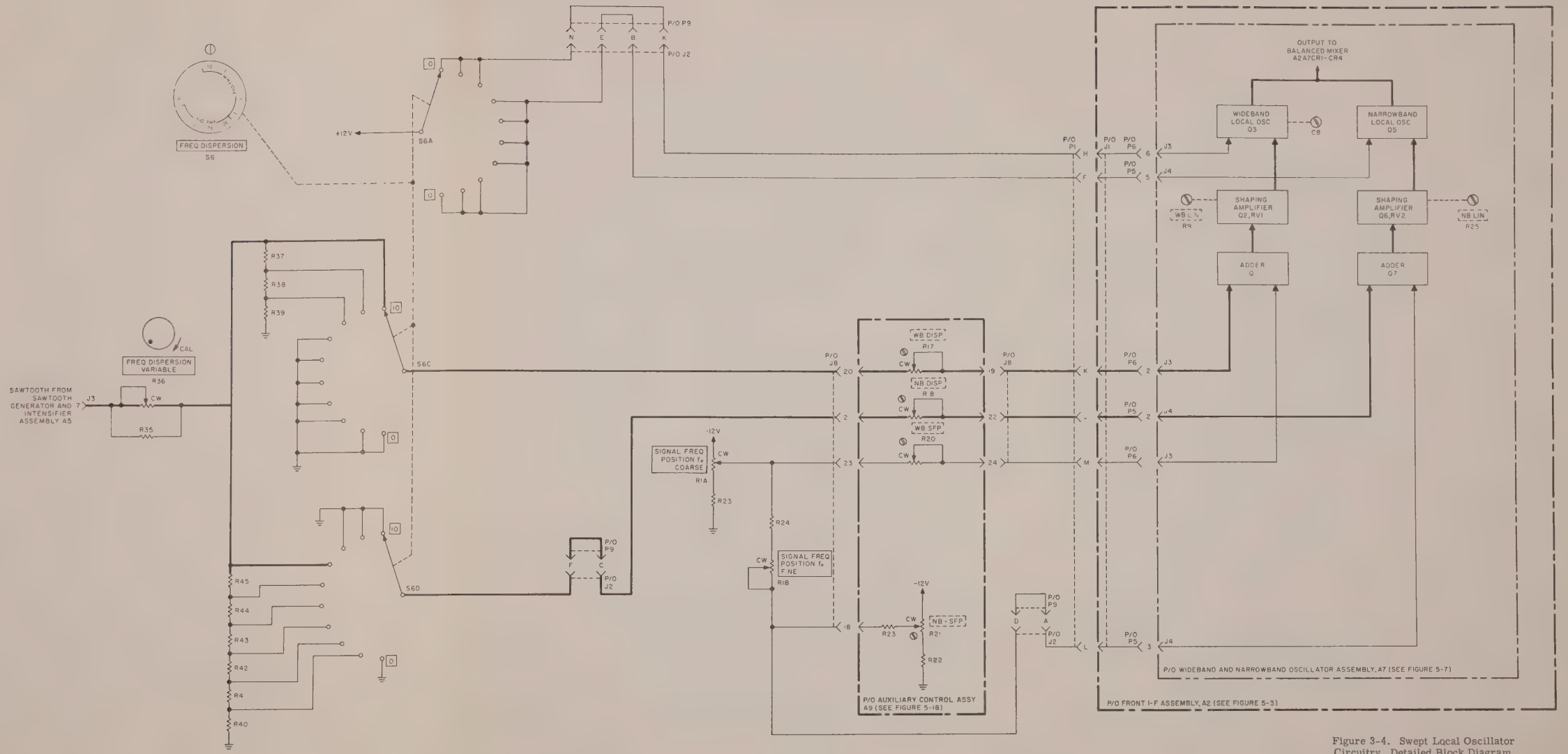


Figure 3-4. Swept Local Oscillator Circuitry, Detailed Block Diagram

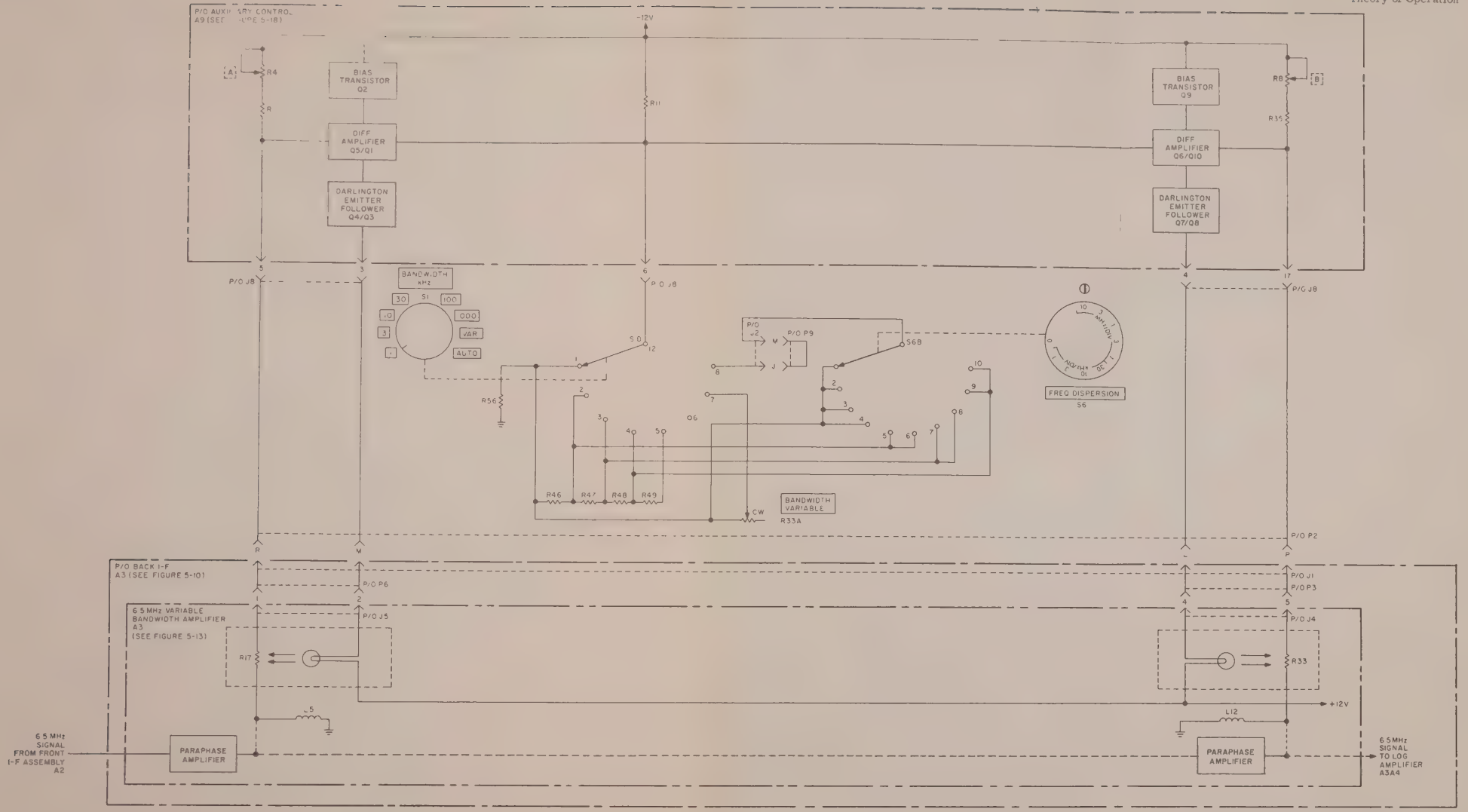


Figure 3-5. Bandwidth Control Circuitry, Detailed Block Diagram

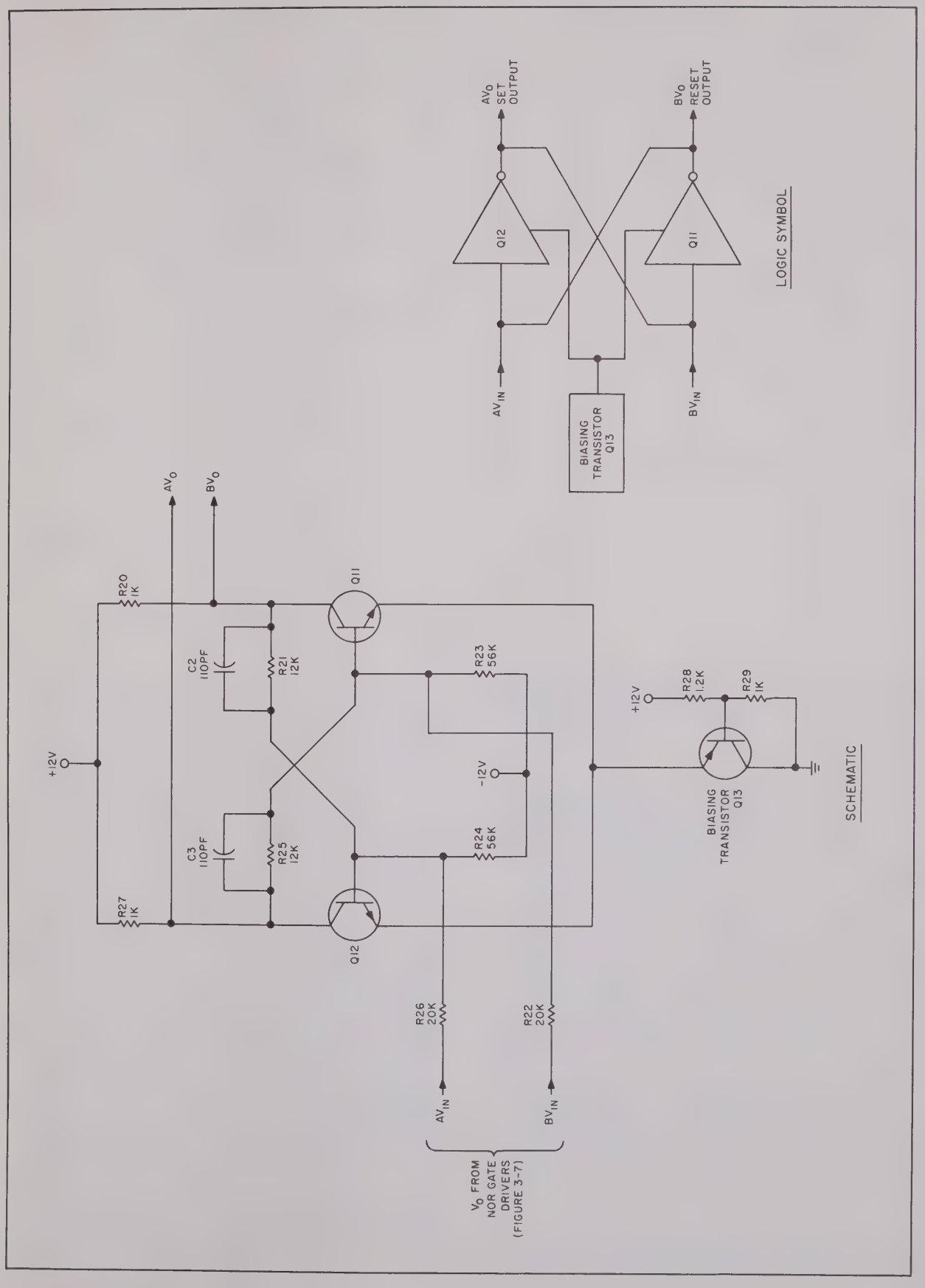


Figure 3-6. Sweep Gate Flip-flop

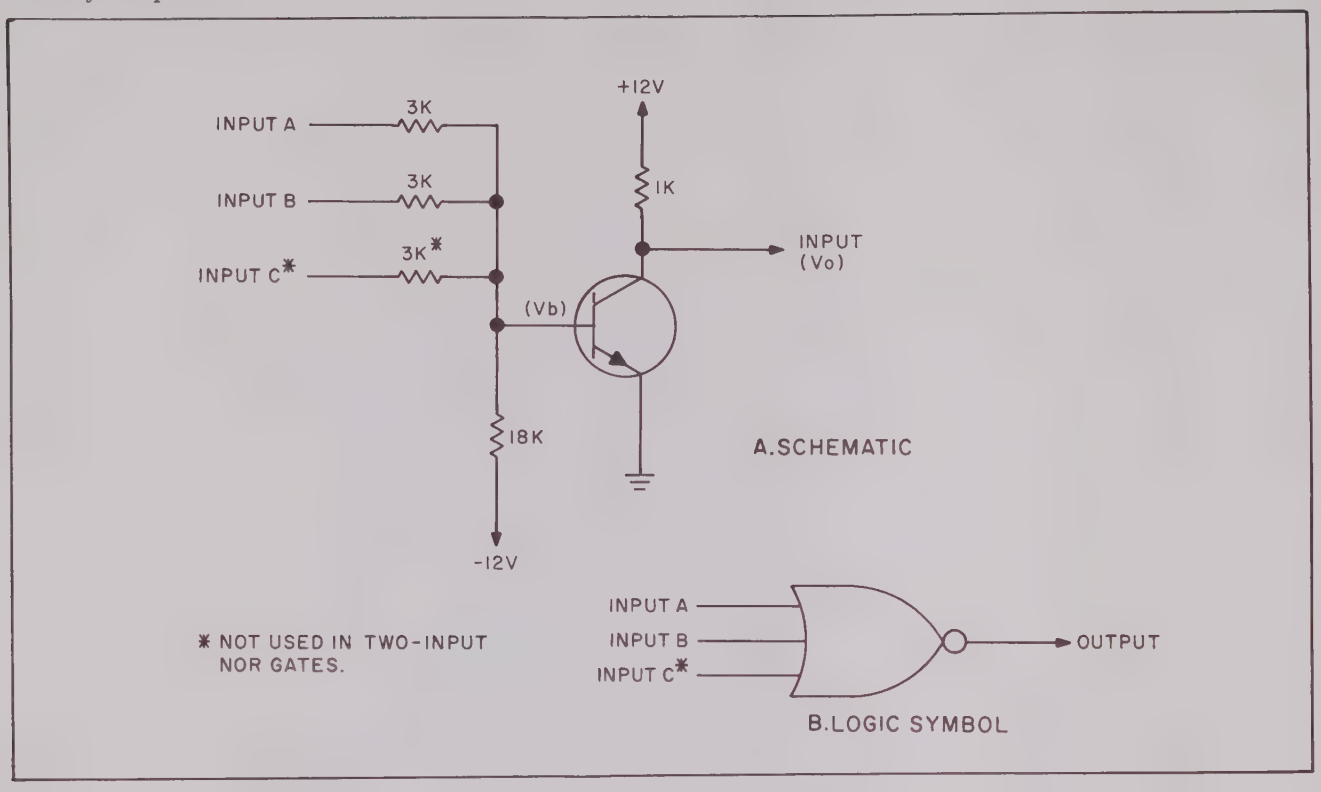


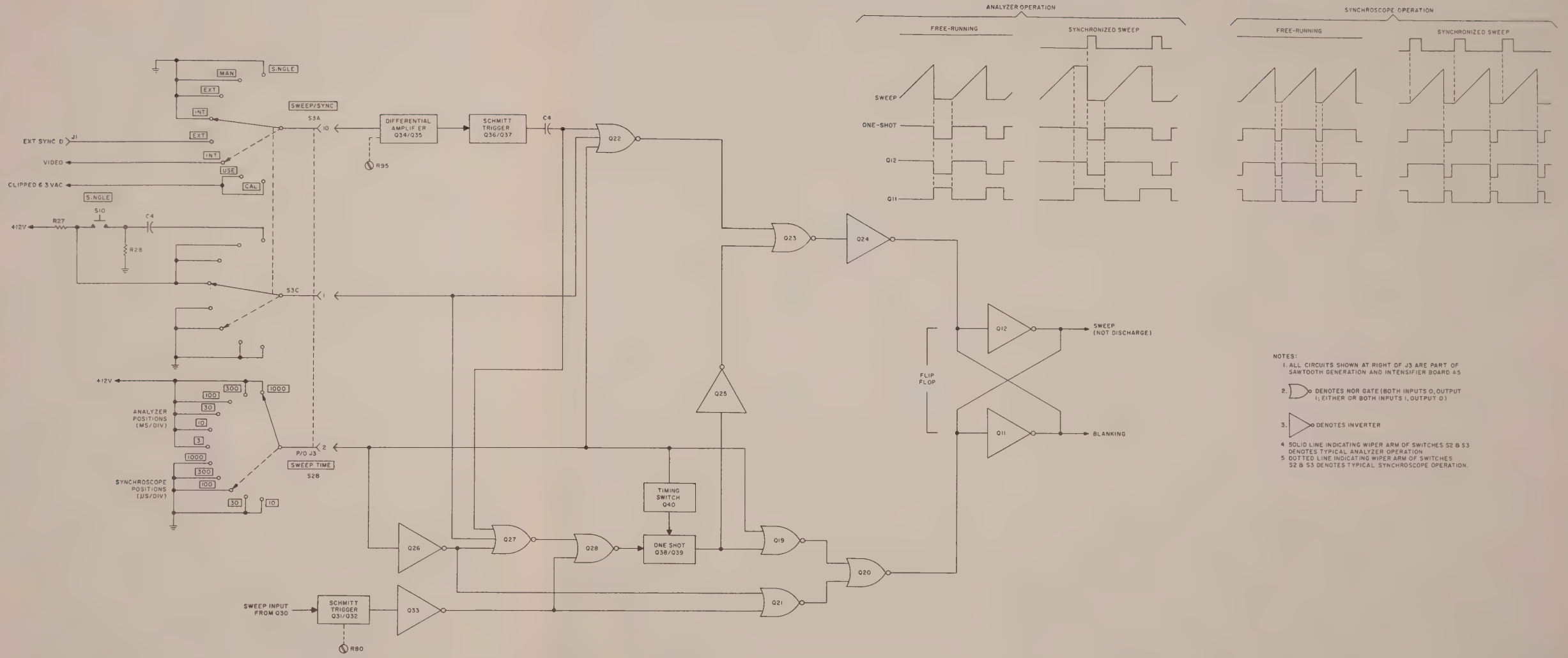
Figure 3-7. Basic NOR Gate

applied to NOR gate A5Q20, (other inputs are 0), produces the required 0 base input to A5Q11 necessary to reset the sweep gate transistor and apply a blanking pulse to the CRT circuit.

3-38. A measured time interval must lapse before the next sweep gate is issued, to permit full retrace after the blanking pulse is initiated. One shot A5Q38/A5Q39 provides this time interval. The 0 output from inverter A5Q33, which initiated the blanking pulse, is also applied to NOR gate A5Q28. Concurrently, a 1 from the wiper arm of SWEEP/SYNC switch S3C is inverted when coupled through NOR gate A5Q27 to A5Q28. Both inputs to A5Q28 generate a 1 output which triggers one shot A5Q38/A5Q39. The one shot output is a 0, coupled through inverter A5Q25, and the resultant 1 output is again inverted when coupled through NOR gate A5Q23. The 0 output of A5Q23 is inverted and applied as a 1 to the base of sweep gate transistor A5Q12 permitting this transistor to be reset, (refer to paragraphs 3-33 and 3-34) which results in the discharge of the sawtooth and in turn returns Schmitt trigger A5Q31/32 to its quiescent state. The 0 output of this Schmitt trigger results in a 1 input to sweep gate transistor A5Q12. Consequently, for as long as the one shot output is 0, the sweep gate flip flop remains reset to permit full retrace.

3-39. When the one shot output returns to the quiescent 1 output, a 0 is applied to the base of A5Q12 and the sweep gate flip flop is set. The time duration of the one shot output is unaffected by timing switch A5Q40 whenever a 1 is applied to the switch, and when SWEEP switch S2B is in any of the analyzer positions, a 1 is always applied to the timing switch. In the analyzer mode of operation the one-shot output pulse is relatively long so that not only retrace time is available, but also, the current-sensitive inductor in the wideband local oscillator (which could be selected in analyzer operation) has sufficient time for its current flow at the end of each sweep - to build up to its initial value before a new sweep is started. This process is repeated for each sweep.

3-40. When the analyzer is operated with SWEEP/SYNC switch S3 in any of the sync positions (red EXT, INT, USE or CAL) or in the SINGLE position, the sweep gate flip flop is not operated as a standard toggle flip flop; and when a blanking pulse is initiated (A5Q11 is cutoff) the sweep gate output (A5Q12 also cutoff) can be available. As in the previous paragraphs, the 0 output of inverter A5Q33 results in a blanking pulse; but, in sync operation one shot A5Q38/A5Q39 is not tripped; therefore the 0 input to the base of A5Q12 remains, keeping that transistor cut off. The 1 output of A5Q12 remains until the 0 input applied to its base is removed. To trip the one shot, a 1 output from A5Q28 is required and it is only made available after other actions are taken. The 0 output from A5Q33 cannot produce a 1 output from NOR gate A5Q28 because the output of NOR gate A5Q27



NOTES:
1. ALL CIRCUITS SHOWN AT RIGHT OF J3 ARE PART OF SAWTOOTH GENERATION AND INTENSIFIER BOARD A5
2. DENOTES NOR GATE (BOTH INPUTS 0, OUTPUT 1; EITHER OR BOTH INPUTS 1, OUTPUT 0)
3. DENOTES INVERTER
4 SOLID LINE INDICATING WIPER ARM OF SWITCHES S2 & S3 DENOTES TYPICAL ANALYZER OPERATION
5 DOTTED LINE INDICATING WIPER ARM OF SWITCHES S2 & S3 DENOTES TYPICAL SYNCHROSCOPE OPERATION.

Figure 3-8. Sweep Control Circuitry, Detailed Block Diagram

is a 1 (all of its inputs are 0's: the output of Schmitt trigger A5Q36/Q37 is a 0 in the absence of a sync pulse; the input from SWEEP/SYNC switch S3C is a 0, assuming that SINGLE pushbutton S10 has not been pressed; and the output of inverter A5Q20 is a 0 when any of the analyzer positions of SWEEP switch A2 are selected). When the SINGLE pushbutton is pressed, a 1 is capacitively coupled to the contacts of switch S3C which applied it to NOR gate A5Q27, one shot A5Q38/39 is tripped, and the sweep gate output is terminated (A5Q12 is turned on). The sweep gate becomes available again when the one-shot pulse ends. In addition to SINGLE position operation, synchronizing pulses for sweep gate termination can be coupled through the contacts of SWEEP/SYNC switch S3A to differential amplifier A5Q34/Q35. If the sync pulse amplitude is above a preset level set by potentiometer R95, Schmitt trigger A5Q36/Q37 is tripped. The resultant 1 output of the Schmitt trigger is coupled through capacitor C4 to NOR gate A5Q27. Sweep gate termination takes place, for one shot A5Q38/39 is tripped by coupling the sync pulse through NOR gates A5Q27 and A5Q28 (previously described).

3-41. When SWEEP switch S2B is set to any of the synchroscope, uS/DIV positions, SWEEP/SYNC switch S3A is usually set to a sync position (red EXT, INT or USE). A sync pulse is then used to initiate the sweep gate, while retrace and blanking occur when the sweep sawtooth voltage indicates full-scale deflection. During synchroscope operation NOR gate A5Q21 is by-passed and the output of one shot A5Q38/Q39 is used both for blanking and sweep gate termination. The 0 output from inverter A5Q33, indicating full-scale sweep deflection, is applied to NOR gate A5Q28. The other input to this NOR gate is always a 0 in synchroscope operation, for the wiper arm of switch S2B is always at 0; and through the double coupling of inverter A5Q26 and NOR gate A5Q27, a 0 is applied to NOR gate Q28. Therefore the output of NOR gate A5Q28 becomes a 1 when the sweep reaches full-scale deflection. A 1 is produced at the output and one shot A5Q38/Q39 is triggered. The resultant 0 output pulse is applied to NOR gate A5Q19, for blanking, and inverter A5Q25, to permit sweep gate termination. With 0 inputs applied to A5Q19 a 1 becomes its output which is inverted and coupled through NOR gate A5Q20 to reset sweep gate flip flip A5Q11/Q12. (The other input to NOR gate A5Q20 is always a 0 in this mode because of the SWEEP switch setting.) The sweep gate flip flop is able to reset (both stages change state) because the one shot 0 output is inverted and coupled through each of stages inverter A5Q25, NOR gate A5Q23 and inverter A5Q21 to place a 1 on the base of transistor A5Q12. (Refer to paragraph 3-34 for a discussion of the flip flop operation.)

3-42. Timing switch Q40, enabled by a 0 input from SWEEP switch S2B, changes the rc time constant of one shot A5Q38/Q39 to reduce the time duration of the one shot output. The shorter time duration allows for the faster sweep rates employed in the synchroscope mode of operation. After retrace, the next sweep is begun by the application of an incoming sync pulse to differential amplifier A5Q34/A5Q35 which in turn trips Schmitt trigger A5Q36/Q37. Capacitor coupling applies a 1 to NOR gate A5Q22. The NOR gate inverts the 1 input (all other inputs from switches S3C and S2B are 0's) and applies a 0 to NOR gate A5Q23; the one shot has returned to the stable 1 state and inverter A5Q25 has a 0 output. The output from A5Q23 is a 1, inverted by A5Q24 and a 0 is applied to the base of A5Q12 setting the sweep gate flip flop. Both flip flop stages change state, initiating the sweep gate and terminating the blanking pulse, for the 0 input is removed from the base of A5Q11 when the one shot output coupled through A5Q19 and A5Q20 returns to the 1 level. In synchroscope operation, the time between sweeps is kept to a minimum for the CRT brightness would be too low, if, at high sweep speeds, the time between sweeps is kept relatively long.

3-43. When the unit is used as a standard free-running oscilloscope or a high-sweep-speed analyzer, the SWEEP/SYNC switch is set to INT SWEEP (black). Sweep gate termination and blanking initiation takes place in the same manner described for synchroscope operation (paragraph 3-31 through 3-39). However, sweep gate initiation and blanking termination are caused by the trailing-edge of the one shot output pulse similar to analyzer operation. The output of NOR gate A5Q22 is a 0 for SWEEP/SYNC switch S3C applies a 1 input to the NOR gate; and the output of inverter A5Q25 is also a 0 when the one shot output is terminated. All 0 inputs to NOR gate A5Q23 apply a 1 to inverter A5Q24 where the signal is inverted, applying a 0 set pulse to the base of A5Q12. The sweep trace begins again.

Note

High-speed analyzer operation should be restricted to narrow-band operation since the one-shot pulse duration is not sufficient in high speed to enable the current in the current-controlled inductor of the wideband local oscillator to reach its maximum value in the limited time between successive sweeps.

3-44. Sweep Generator. The sweep generator (figure 3-9) consists of a constant current charge circuit comprising the sweep capacitor (C1, C2, or C3) selected by SWEEP switch S2A, constant current source A5Q16, and the sweep resistor R18, R16, R17, or R15) selected by SWEEP switch S2C. The rate at which the sweep voltage increases - the sweep capacitor charge rate - depends upon the capacitance of the selected sweep capacitor, and the current in A5Q16. The current is determined by the resistance of the selected sweep resistor and the voltage applied to the base of A5Q16 by SWEEP VARIABLE control R14. The more negative the base voltage, the greater the current in A5Q16 and the faster the sweep. SWEEP CAL screwdriver adjustment A9R24 calibrates the SWEEP switch positions when the SWEEP VARIABLE control is fully cw.

3-45. When the positive sweep gate is applied from sweep gate flip-flop A5Q11/Q12, A5Q14 is held off; and as a result, A5Q15 is held off. Diode A5CR1

blocks the positive voltage at the collector of A5Q15 from the sweep circuit. During the sweep gate interval, the sweep capacitor is charged through the series network consisting of selected resistor R15 through R18, constant current source A5Q16, and A5Q17 of the biasing network causing a sawtooth voltage to be developed across the sweep capacitor. The sum of this sawtooth voltage and the negative dc bias established by the biasing network Q17/Q18 make up the sweep voltage which is coupled through the contacts of SWEEP/SYNC switch S3D (except in MAN and EXT SWEEP) to an emitter follower output circuit. The biasing network is a complementary emitter follower whose output is set by screwdriver adjustment A5R37. When A5Q12 of the sweep control circuit is turned on, its output becomes 0, turning on A5Q14, which in turn turns on A5Q15, which discharges the sweep through the capacitor and retrace occurs.

3-46. Darlington emitter follower A5Q29, in series with A5Q30, applies the buffered output to the sweep control circuits, to the swept local oscillator circuits, and to the horizontal deflection circuits. The adjusted output of the H SIZE potentiometer is applied through the horizontal deflection amplifier in assembly A4 to the CRT. This adjustment, A5R37, establishes the position of the left edge of the trace. The portion of the sweep voltage developed across R30 is applied to the H output pin J1-A, for remote operation or X-Y plotting.

3-47. In MAN, the sweep voltage is a dc voltage that can be varied by SWEEP MANUAL control R26; as before the biasing network established the minimum voltage for the sweep. In the black EXT position, an external sweep applied at J1-E, replaces the internally developed sweep.

3-48. INTENSIFICATION CIRCUITS. The intensification circuits produce an output to the CRT control grid that blanks the screen when the sweep capacitor is not being charged, intensifies the trace in accordance with the BRIGHTNESS control setting, or intensifies only signals whose amplitudes exceed a value set by the INTENSIFIER control. Figure 3-10 is the detailed block diagram of the intensification circuits.

3-49. The video output of the auxiliary output amplifier A4Q4, Q5, and Q6 is applied to one input of differential amplifier A5Q2/Q3 where it is compared with the dc voltage established by the setting of the INTENSIFIER control. If the INTENSIFIER is set fully ccw, the output of difference amplifier A5Q2/Q3 is always positive, and the output of Schmitt trigger A5Q4/Q5 (held in the "triggered" state) is a positive dc voltage. This dc output of A5Q4/Q5 turns on pulse amplifier A5Q6, which is a common-base amplifier whose dc base voltage is determined by the setting of the BRIGHTNESS control. When the INTENSIFIER control is turned clockwise, any video components that are greater in amplitude than the intensifier voltage produce a positive pulse output from the differential amplifier. This positive output triggers Schmitt trigger A5Q4/Q5 which produces a positive pulse. This positive pulse turns on pulse amplifier A5Q6 which gates the voltage determined by the setting of the BRIGHTNESS control. The output of the pulse amplifier therefore is a positive pulse or a dc level whose amplitude is established by the BRIGHTNESS control. This positive pulse or dc level is applied to differential amplifier A5Q7/Q8 whose second input is the blanking pulse that is applied from flip-flop A5Q11/Q12 through emitter follower A5Q16. During the time of the blanking pulse, the output of the differential amplifier is a negative-going pulse; during each sweep, the output of the differential amplifier is a dc level that is too low to intensify the screen except when a video pulse exists that exceeds the voltage set by the INTENSIFIER control; at this time, the output is controlled by the setting of the BRIGHTNESS control. This composite signal is applied through emitter follower A5Q9 and the output circuit of the 2500 volt power supply to the control grid of CRT V1. The voltage applied to the CRT grid is therefore 2500 volts plus the output of emitter follower A5Q9; this configuration permits the CRT grid to be operated at approximately 2500 volts while the circuits in the sawtooth generator intensifier board A5 operate at normal transistor voltages.

3-50. POWER SUPPLIES. The dc power supplies in the Main Frame include the +300 volt unregulated, +100 volt regulated, +12 volt regulated, -12 volt regulated, and high voltage CRT power supplies. These supplies provide the operating voltages for the Main Frame and for the associated tuning head. In addition, +18 volts unregulated from the rectifier and filter of the +12 volt supply is applied to the tuning head.

3-51. Input Circuit (figure 5-1). 115 volt or 230 volt single-phase ac power is applied from power plug P8 through fuses F1 and F2, power switch S7 (ganged to the SCALE ILLUMINATION control), and 115V--230V switch S9 to power transformer T1. When S9 is set to 115V, the two primary windings of T1 are connected in parallel and, with a 115 volt input, the voltage across each winding is 115 volts. When S9 is set to 230 V, the windings are connected in series and, with a 230 volt input, the voltage across each winding is 115 volts. The series-circuit current is equal to the current that would flow in each of the parallel-connected windings. Thus, the input current in 230-volt operation is half that in 115-volt operation. To maintain the same degree of protection in 230-volt operation, the current rating of the fuses should be half that of the fuses used in 115-volt operation.

3-52. +300 Volt Power Supply. The +300 volt power supply contains full-wave rectifier A7CR1, CR2, filter A7C1, R1, C2, and bleeder resistor A7R2.

3-53. +100 Volt Power Supply. The +100 volt power supply contains full-wave rectifier A7CR3, CR4, filter capacitor A7C3, bleeder resistor A7R3, fuse A7F1, and a voltage and current regulator consisting of circuits on board A8 and power transistor (series regulator) Q5. The regulator circuit

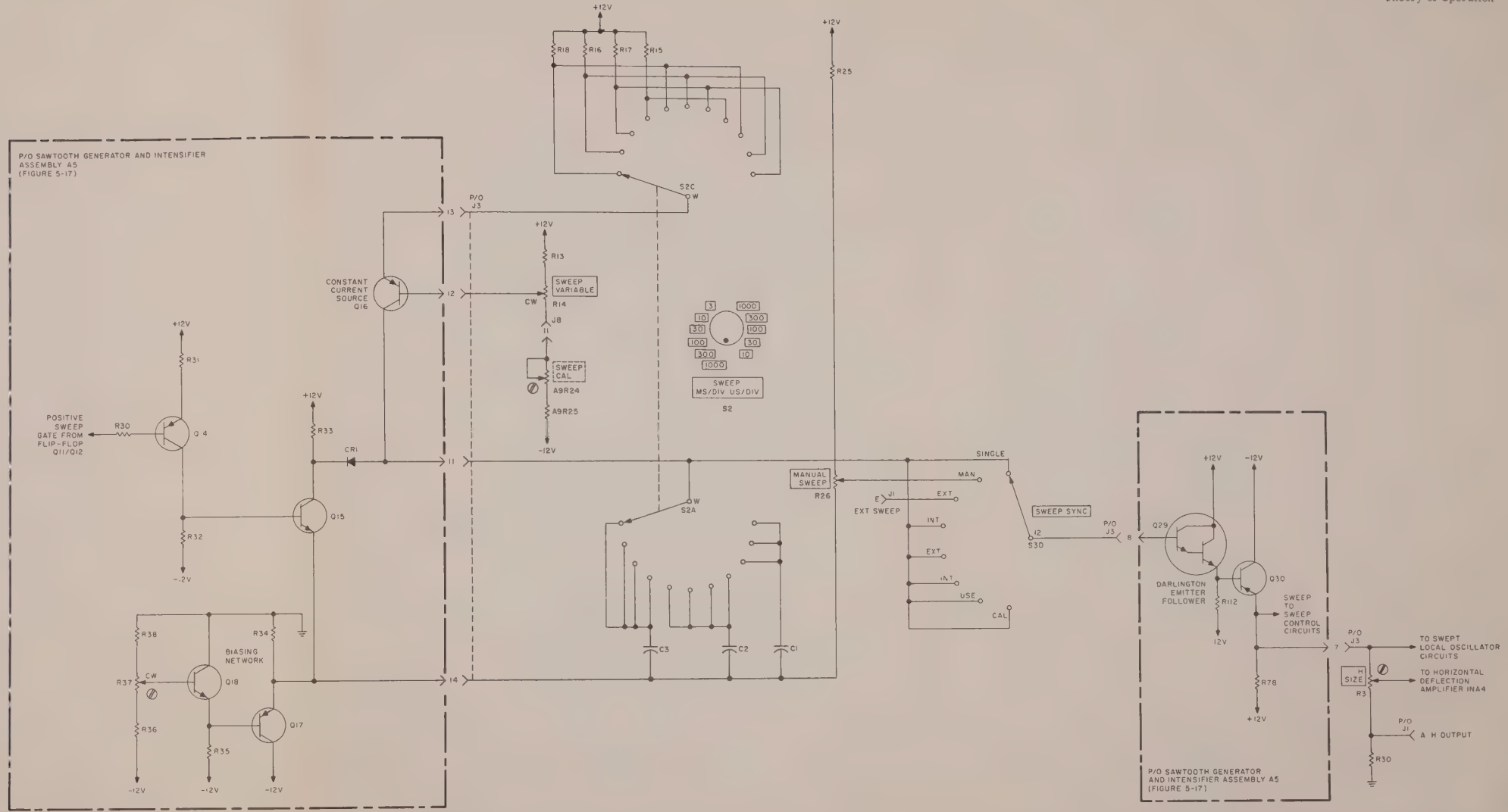


Figure 3-9. Sawtooth Generator Circuitry, Detailed Block Diagram

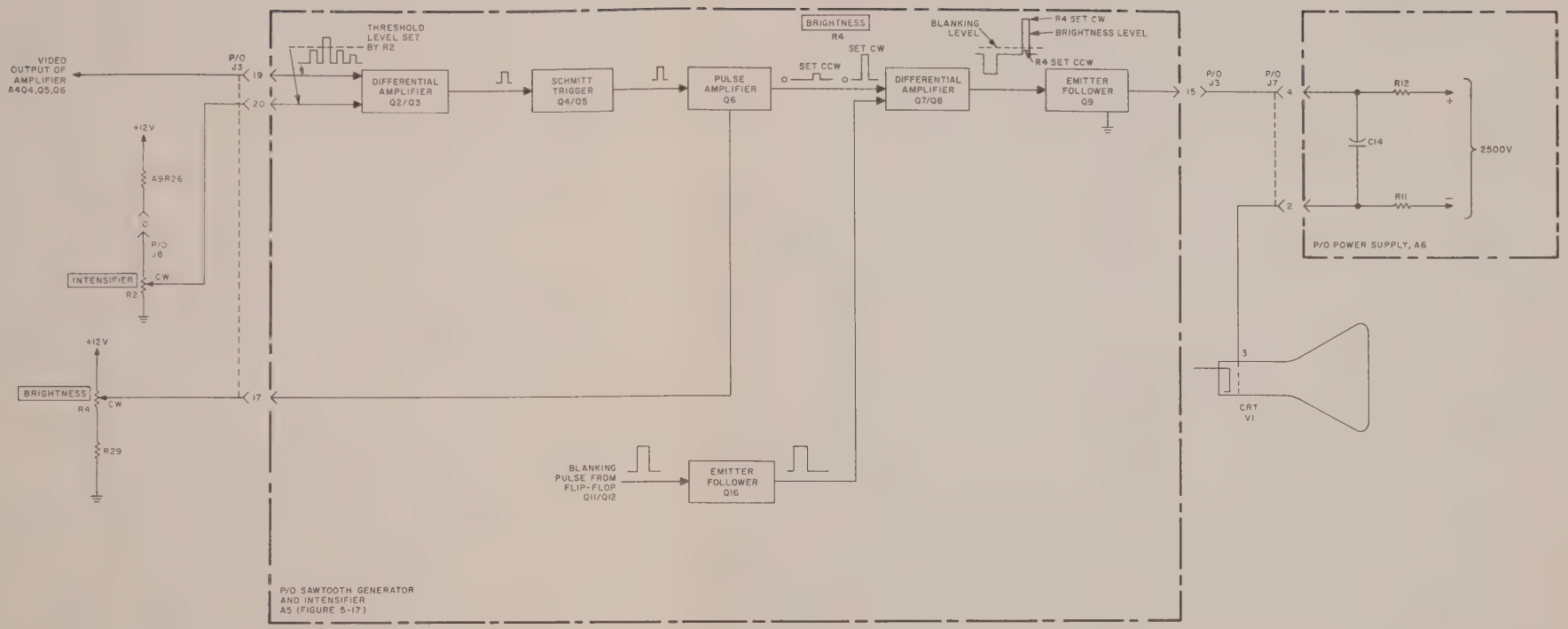


Figure 3-10. Intensifier and Blanking Circuitry, Detailed Block Diagram

controls the conduction through Q5 to regulate the output voltage and current. If the output voltage rises slightly, the voltage applied to difference amplifier A8Q4/Q3 rises, conduction in A8Q4 increases, increasing the drop across collector load resistors A8R1 and A8R2, and decreasing its collector voltage. As a result, the base voltage of A8Q1 decreases, decreasing conduction in emitter follower A8Q1 and in series regulator Q5. Turning screwdriver adjustment A8R10 counterclockwise has the same effect on the regulator as an increased output voltage would (increasing the voltage at A8Q4), and the regulator therefore reduces the output voltage to compensate for such an adjustment. If the load current increases slightly, it would produce an increased voltage drop across A8R5, which would increase conduction in A8Q2, whose reduced collector voltage would reduce conduction in emitter follower A8Q1 and in series regulator Q5.

3-54. +12 Volt and -12 Volt Power Supplies. The +12 volt and -12 volt supplies are identical; therefore only the +12 volt supply is described. A portion of the positive output is sensed by the voltage divider consisting of A8R18, R19, and R20. This voltage is applied to difference amplifier A8Q6/Q7 where any change is compared with the reference supplied by Zener diode CR3. The amplified voltage change (in phase) from A8Q6 is applied through emitter follower A8Q5 to the base of series regulator Q2. If the output voltage rises, the base voltage of Q2 increases and conduction in Q2 decreases returning the output voltage to +12 volts. If the output current increases, the voltage across A8R10 increases, decreasing conduction in series regulator Q1.

3-55. CRT Power Supplies. The CRT power supplies utilize a square-wave oscillator whose output is stepped up by transformer T1 to the high voltage ac, which is rectified by a voltage doubler and filtered to provide +2500 volt and -2500 volt outputs. The oscillator is a free-running multivibrator with a RC time constant in the base drive, which determines the frequency of oscillation. Diodes A6CR7, CR8 serve to protect the base emitter junction from reverse breakdown. When power is first applied, capacitors A6C5 and A6C4 start to charge through A6R2 and trigger unijunction transistor A6Q3. The pulses generated by A6Q3 trigger A6Q1 to ensure operation of the free-running multivibrator. After a few cycles of operation, the charge across A6C5 will have built up sufficiently to block the unijunction circuit; the multivibrator continues to operate without this triggering. When the equipment is turned off, capacitor A6C5 discharges rapidly through A6CR1 so that the unijunction circuit will operate immediately upon re-energization. The frequency at which the oscillator operates (approximately 20 kHz) is not critical since the output is rectified to produce the dc supply voltages.

3-56. POWER DISTRIBUTION.

3-57. The source and distribution of dc voltages are listed in table 3-1. Table 3-1 lists all circuit boards and other reference-designated assemblies and indicates which, if any, of the dc voltages are used in each. For complete interconnections, refer to figures 5-1, 5-3, and 5-10.

TABLE 3-1. DC VOLTAGE DISTRIBUTION

Board (Mating connector)	Pin at which Voltage is Connected				
	+300V (A7-6)	+100V (A8-11)	+12V (A8-23)	-12V (A8-2)	GND
A1	-	-	-	-	-
A2(P1)	-	D	C	B	A
A2A1(A2P2)	-	-	3	-	1
A2A2(A2P3)	-	-	-	-	1
A2A3(A2P4)	-	-	1	-	2
A2A4	-	-	-	-	-
A2A5	-	-	-	-	-
A2A6	-	-	-	-	-
A2A7	-	A2P5-1	A2P6-5	A2P6-4	A2P6-3
A2A8(A2P7)	-	-	1	2	4
A2A9(A2P8)	-	-	3	1	2

TABLE 3-1. DC VOLTAGE DISTRIBUTION (Cont'd)

Board (Mating connector)	Pin at which Voltage is Connected				
	+300V (A7-6)	+100V (A8-11)	+12V (A8-23)	-12V (A8-2)	GND
A3(P2)	-	-	C	B	A
A3A1(A3P1)	-	-	-	1	3
A3A2(A3P2)	-	-	-	1	2
A3A3(A3P3)	-	-	3	7	1
A3A4(A3P4)	-	-	3	1	2
A3A5(A3P5)	-	-	1	3	2
A4(J4)	14	-	7	9	5, 11
A5(J3)	-	16	9, 18	4, 21	5, 22
A6(J7)	-	-	21	22	15, 20
A7(J5)	-	-	-	-	
A8(J6)	-	-	-	-	9
A9(J8)	9	-	1, 13	5	2

SECTION IV
MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance, alignment and calibration instructions for the MF-100. Included is a list of test equipment necessary to maintain the MF-100, minimum performance standards checks to evaluate if the MF-100 operates within the specifications listed in paragraph 1-7, symptomatic troubleshooting procedures to localize a malfunction to an individual circuit or subassembly and alignment and calibration procedures necessary to restore the MF-100 to proper operating condition after the required repairs and/or replacements have been effected.

4-3. REQUIRED TEST EQUIPMENT

4-4. The test equipment required for the maintenance of the MF-100 is listed in table 4-1. Equipment having equivalent characteristics may be substituted for those specified.

4-5. MINIMUM PERFORMANCE STANDARDS CHECKS.

4-6. The minimum performance standards checks is a systematic procedure for determining if the MF-100 is operating within the specifications listed in paragraph 1-7. Should the MF-100 fail to provide the specified "acceptable indication," the equipment is not functioning properly and the operator should refer to the applicable troubleshooting, replacement, repair, alignment and/or calibration procedure to return the equipment to proper operating condition. Set the MF-100 controls as listed in table 4-2 prior to initiating the minimum performance standards checks detailed in table 4-3.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Manufacturer and Model
Hewlett-Packard 608C Signal Generator
Tektronix Type 180A Time-Mark Generator
Hewlett-Packard 8406A Comb Generator
Hewlett-Packard 651B Test Oscillator
Narda 501B Detector
Microlab DA-3FB Resistive T
Hewlett-Packard 130C Oscilloscope
Kay 33-0(432C) Step Attenuator
Kay 70-0(1/432C) Step Attenuator
Jerrold 900B Sweep Signal Generator
RCA WV98C Senior Voltohmyst
Hewlett-Packard 132A Dual Beam Oscilloscope
Hewlett-Packard 606B Signal Generator
The Singer Company-Empire F-1A/NF-105 Tunable Rejection Filter

TABLE 4-2. INITIAL CONTROL SETTINGS FOR MINIMUM PERFORMANCE STANDARDS CHECKS

Control	Setting
SCALE ILLUMINATION control	Fully ccw (PWR OFF)
FOCUS control	Mid-range
BRIGHTNESS control	Mid-range
INTENSIFIER control	Fully ccw
IF ATTENUATOR switches	00 dB
FREQ DISPERSION switch	.3 MHz/DIV

TABLE 4-2. INITIAL CONTROL SETTINGS FOR MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Control	Setting
FREQ DISPERSION VARIABLE control	Fully cw (CAL)
MARKER MODULATION switch	OFF
MARKER LEVEL control	Fully ccw (OFF)
AMPLITUDE SCALE switch	LOG
IF GAIN control	Fully ccw
SIGNAL FREQ POSITION f_o COARSE control	Mid-range
SIGNAL FREQ POSITION f_o FINE control	Mid-range
BANDWIDTH switch	100 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	Fully cw (CAL)
SWEEP/SYNC switch	INT SWEEP (black)
MANUAL control	Any

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS

Step	Purpose	Procedure	Acceptable Indication
1	Preparation for checkout.	Couple the MF-100 to line power, rotate the SCALE ILLUMINATION control clockwise from its PWR OFF setting and adjust for a convenient graticule illumination. Allow the MF-100 to warm up for at least 10 minutes. Adjust the FOCUS and BRIGHTNESS controls to obtain a sharply focused and clearly visible trace. Rotate the IF GAIN control clockwise so that the bottom of the trace coincides with the LOG scale 60 DB line. Adjust the H POS screwdriver control to center the display on the screen and then adjust the H SIZE screwdriver control so that the waveform extends one-quarter division beyond the extreme left- and right-hand vertical graticule lines. Rotate the IF GAIN control fully counterclockwise and adjust the V POS screwdriver control so that the base of the displayed waveform coincides with the lowest horizontal graticule line. Tune an HP 608C Signal Generator to 160 MHz and adjust for a cw output level of -45 dBm. Couple the signal generator to the rear panel IF INPUT connector. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to center the displayed pip about the vertical graticule f_o line.	Proper display is presented on screen.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
2	To evaluate accuracy of LOG display.	a. Insert Kay 33-0(432C) and 70-0(1/432C) Step Attenuators in series between the signal generator and the MF-100 rear panel IF INPUT connector. Adjust the step attenuators for 0-dB insertion. Set the FREQ DISPERSION switch to .1 MHz/DIV and adjust the IF GAIN control to obtain a noise display one box high. Reset the BANDWITH switch to 10 kHz and adjust the signal generator output level to obtain a pip peak coincident with the LOG scale 0 dB line. Note the signal generator output level.	a. Signal level required for full-scale LOG display is between -40 and -50 dBm.
		b. Insert external step attenuation until the pip peak is coincident with the LOG scale 10 dB line. Note the total external attenuation inserted.	b. Between 8 and 12 dB of external step attenuation required to position the pip peak at the LOG scale 10 dB line.
		c. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 20 dB line. Note the total external attenuation inserted.	c. Between 18 and 22 dB of external step attenuation required to position the pip peak at the LOG scale 20 dB line.
		d. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 30 dB line. Note the total external attenuation inserted.	d. Between 28 and 32 dB of external step attenuation required to position the pip peak at the LOG scale 30 dB line.
		e. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 40 dB line. Note the total external attenuation inserted.	e. Between 38 and 42 dB of external step attenuation required to position the pip peak at the LOG scale 40 dB line.
		f. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 50 dB line. Note the total external attenuation inserted.	f. Between 48 and 52 dB of external step attenuation required to position the pip peak at the LOG scale 50 dB line.
		g. Insert additional external step attenuation until the pip peak is coincident with the LOG scale 60 dB line. Note the total external attenuation inserted.	g. Between 58 and 62 dB of external step attenuation required to position the pip peak at the LOG scale 60 dB line.
3	To evaluate range of IF GAIN control.	a. Adjust the external step attenuators for 0 dB insertion, rotate the IF GAIN control fully counterclockwise and adjust the signal generator output level to obtain a pip peak coincident with the LOG scale 20 dB line.	
		b. Rotate the IF GAIN control fully clockwise and insert external step attenuation to once again obtain a pip peak coincident with the LOG scale 20 dB line. Note the total external attenuation inserted.	b. At least 20-dB of external attenuation required to return the pip peak to the LOG scale 20 dB line.
4	To evaluate accuracy of LIN display.	a. Set the IF ATTENUATOR switches to 40 dB, set the external step attenuators for 0 dB insertion, set the AMPLITUDE SCALE switch to LIN and rotate the IF GAIN control fully counterclockwise. Adjust the V POS screwdriver control, if necessary, to position the	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
4 (Cont)		base of the displayed waveform coincident with the lowest horizontal graticule line. Adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.	
		b. Insert external step attenuation until the pip peak is coincident with the LIN scale 0.8 line. Note the total external attenuation inserted.	b. Between 1.6 and 2.2 dB of external step attenuation required to position the pip peak at the LIN scale 0.8 line.
		c. Insert additional external step attenuation until the pip peak is coincident with the LIN scale 0.6 line. Note the total external attenuation inserted.	c. Between 4.0 and 4.9 dB of external step attenuation required to position the pip peak at the LIN scale 0.6 line.
		d. Insert additional external step attenuation until the pip peak is coincident with the LIN scale 0.4 line. Note the total external attenuation inserted.	d. Between 7.2 and 8.6 dB of external step attenuation required to position the pip peak at the LIN scale 0.4 line.
		e. Insert additional external step attenuation until the pip peak is coincident with the LIN scale 0.2 line. Note the total external attenuation inserted.	e. Between 12.8 and 15.4 dB of external step attenuation required to position the pip peak at the LIN scale 0.2 line.
5	To evaluate accuracy of PWR display.	a. Set the external step attenuators for 0 dB insertion, set the AMPLITUDE SCALE switch to PWR and, if necessary, adjust the V POS screwdriver control to position the base of the displayed waveform coincident with the lowest horizontal graticule line. Adjust the signal generator output level to obtain a pip peak coincident with the PWR scale 1.0 line.	
		b. Insert additional external attenuation until the pip peak is coincident with the PWR scale 0.6 line. Note the total external attenuation inserted.	b. Between 2.0 and 2.4 dB of external step attenuation required to position the pip peak at the PWR scale 0.6 line.
		c. Insert additional external attenuation until the pip peak is coincident with the PWR scale 0.4 line. Note the total external attenuation inserted.	c. Between 3.6 and 4.3 dB of external step attenuation required to position the pip peak at the PWR scale 0.4 line.
		d. Insert additional external attenuation until the pip peak is coincident with the PWR scale 0.2 line. Note the total external attenuation inserted.	d. Between 6.4 and 7.7 dB of external step attenuation required to position the pip peak at the PWR scale 0.2 line.
6	To evaluate accuracy of i-f attenuator.	a. With the AMPLITUDE SCALE switch set to PWR, insert a total of 66 dB of external step attenuation, adjust the signal generator for a cw output of +5 dBm and adjust the IF GAIN control to obtain a pip peak coincident with the PWR scale 1.0 line.	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
6 (Cont)		b. Set the IF ATTENUATOR switches as indicated below and, for each setting, remove external step attenuation until the pip peak is coincident with the PWR scale 1.0 line. Note the remaining external attenuation inserted after each step. IF ATTENUATOR Switch Setting 10 DB 20 DB 30 DB 40 DB 50 DB 60 DB	b. IF ATTENUATOR Switch Setting — Remaining External Step Attenuation 10 DB — 55.5 to 56.5 dB 20 DB — 45.0 to 47.0 dB 30 DB — 34.5 to 37.5 dB 40 DB — 24.0 to 28.0 dB 50 DB — 13.5 to 18.5 dB 60 DB — 3.0 to 9.0 dB
		c. Reset the external step attenuators for 66 dB insertion, set the IF ATTENUATOR switches to 00 DB and adjust the IF GAIN control, if necessary, to obtain a pip peak coincident with the PWR scale 1.0 line.	
		d. Set the IF ATTENUATOR switches as indicated below and, for each setting of the switches, remove external step attenuation until the pip peak is coincident with the PWR scale 1.0 line. Note the external attenuation remaining after each step. IF ATTENUATOR Switch Setting 01 DB 02 DB 03 DB 04 DB 05 DB 06 DB 07 DB 08 DB 09 DB	d. IF ATTENUATOR Switch Setting — Remaining External Step Attenuation 01 DB — 64.95 to 65.05 dB 02 DB — 63.90 to 64.10 dB 03 DB — 62.85 to 63.15 dB 04 DB — 61.80 to 62.20 dB 05 DB — 60.75 to 61.25 dB 06 DB — 59.70 to 60.30 dB 07 DB — 58.65 to 59.35 dB 08 DB — 57.60 to 58.40 dB 09 DB — 56.55 to 57.45 dB
7	To evaluate dispersion accuracy and linearity.	a. Adjust the signal generator for a cw output level of -45 dBm, set the IF ATTENUATOR switches to 00 DB and set the AMPLITUDE SCALE switch to LOG. Adjust the V POS screwdriver control, if necessary, to position the base of the displayed waveform coincident with the lowest graticule horizontal line. Interconnect the equipment as illustrated in figure 4-1. Adjust the test oscillator for minimum output level. Set the comb generator for 10-MHz markers and set its output level control to mid-range. Set the BANDWIDTH switch to AUTO, set the FREQ DISPERSION switch to 10 MHz/DIV and adjust the IF GAIN control to obtain a noise display one-half division high. Identify the 160-MHz	a. Display dispersion is between 95 and 105 MHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
7 (Cont)		marker by means of the signal generator. After the 160-MHz marker has been located, adjust the signal generator for minimum output level and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Adjust the comb generator for both 10- and 1-MHz markers and determine the display dispersion.	
		b. Determine the maximum and minimum number of markers per graticule division.	b. Display linearity is such that the maximum number of markers per division does not exceed 12 and the minimum number of markers per division is not less than eight (8).
		c. Rotate the FREQ DISPERSION VARIABLE control fully counterclockwise and note the display dispersion.	c. Display dispersion decreases to 28.5 MHz or less.
		d. Repeat step b.	d. Display dispersion decreases to 9.5 MHz or less
		e. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the FREQ DISPERSION switch to 1 MHz/DIV and adjust the comb generator for 10-MHz markers only. Adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line and then reset the comb generator for both 10- and 1-MHz markers. Determine the display dispersion.	e. Display dispersion is between 9.5 and 10.5 MHz.
		f. Repeat step b.	f. Display dispersion decreases to 2.85 MHz or less.
		g. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the FREQ DISPERSION switch to .3 MHz/DIV and adjust the comb generator for 10-MHz markers only. Adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Tune the test oscillator to 300 kHz and increase its output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	g. Display dispersion is between 2.85 and 3.15 MHz.
		h. Rotate the FREQ DISPERSION VARIABLE control fully counterclockwise and adjust the test oscillator frequency to determine the display dispersion.	h. Display dispersion is 950 kHz or less.
		i. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 100 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to .1 MHz/DIV and adjust the SIGNAL	i. Display dispersion is between 950 and 1050 kHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
7 (Cont)		FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line. Increase the test oscillator output level until sidebands appear and then adjust the test oscillator frequency to determine the display dispersion.	
		j. Repeat step h.	j. Display dispersion is 285 kHz or less.
		k. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 30 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 30 kHz/DIV and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	k. Display dispersion is between 285 and 315 kHz.
		l. Repeat step h.	l. Display dispersion is 95 kHz or less.
		m. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 10 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 10 kHz/DIV and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	m. Display dispersion is between 95 and 105 kHz.
		n. Repeat step h.	n. Display dispersion is 28.5 kHz or less.
		o. Rotate the FREQ DISPERSION VARIABLE switch fully clockwise to CAL, tune the test oscillator to 3 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 3 kHz/DIV and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the 160-MHz marker at the graticule f_o vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	o. Display dispersion is between 28.5 and 31.5 kHz.
		p. Repeat step h.	p. Display dispersion is 9.5 kHz or less.
		q. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, tune the test oscillator to 1 kHz and adjust for minimum output level. Set the FREQ DISPERSION switch to 1 kHz/DIV and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE	q. Display dispersion is between 9.5 and 10.5 kHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
7 (Cont)		control to position the 160-MHz marker at the graticule f_0 vertical line. Increase the test oscillator output level until sidebands appear. Adjust the test oscillator frequency to determine the display dispersion.	
		r. Repeat step h.	r. Display dispersion is 2.85 kHz or less.
		s. Rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the FREQ DISPERSION switch to 0 and note the display.	s. Display has constant amplitude across the screen.
8	To evaluate narrowband incidental fm.	Set the FREQ DISPERSION switch to 1 kHz/DIV and adjust the test oscillator for minimum output level. Adjust the SIGNAL FREQ POSITION f_0 FINE control to position the 160-MHz marker at the graticule f_0 vertical line. Set the SWEEP switch to 1000 μS/DIV and note the horizontal variation of marker pip position.	t. Maximum horizontal variation of pip position is 1/3 division (maximum incidental fm of 300 Hz).
9	To evaluate response flatness.	a. Disconnect the equipment from the setup of figure 4-1. Set the SWEEP switch to 3 MS/DIV, set the BANDWIDTH switch to 1000, set the IF ATTENUATOR switches to 40 DB, rotate the IF GAIN control fully counterclockwise, set the FREQ DISPERSION switch to 10 MHz/DIV and set the AMPLITUDE SCALE switch to LIN. Adjust the V POS screwdriver control, if necessary, to position the base of the displayed waveform coincident with the lowest graticule horizontal line.	
		b. Connect an HP608C Signal Generator (tuned to 160 MHz and adjusted for a cw output of -45 dBm) to the rear panel IF INPUT connector and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE controls to position the pip peak at the graticule f_0 vertical line. Adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line. Tune the signal generator ±50 MHz about 160 MHz (while maintaining its output level constant at -45 dBm) and note the frequencies at which the maximum and minimum responses occur. Tune the signal generator to the frequency at which the maximum response occurs and adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line. Tune the signal generator to the frequency at which the minimum response occurs and increase the signal generator output level to position the pip peak coincident with the LIN scale 1.0 line. Note the signal generator output level.	b. Signal generator output does not exceed -43 dBm.
10	To evaluate accuracy of internal markers.	a. Disconnect the signal generator from the rear panel IF INPUT connector. Set the IF ATTENUATOR switches to 00 DB, set the AMPLITUDE SCALE switch to LOG, set the BANDWIDTH switch to VAR, set the FREQ DISPERSION switch to .3 MHz/DIV and adjust the V POS	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
10 (Cont)		screwdriver control, if necessary, to position the trace coincident with the lowest graticule horizontal line. Adjust the IF GAIN control to obtain a noise display one box high. Connect the equipment as illustrated in figure 4-1, with the test oscillator and comb generator set for minimum output level. Set the comb generator for 10-MHz markers and adjust for maximum output level. Identify the 160-MHz marker (using the signal generator) and position this signal at the graticule f_0 vertical line using the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control. Set the signal generator for minimum output level and rotate the MARKER LEVEL control fully clockwise.	
		b. Adjust the BANDWIDTH VARIABLE control and/or FREQ DISPERSION switch, as required, until separation of the two pips is clearly defined. Tune the test oscillator to 50 kHz and increase its output level until sidebands appear about the comb generator 160-MHz marker. Adjust the test oscillator frequency until one of the sidebands coincides with the internal marker pip. Note both the test oscillator frequency (f_1) and which side band (left or right) of the comb generator marker zero-beats with the internal marker.	b. $f_1 \leq 250$ kHz
		c. Set the FREQ DISPERSION switch to 1 MHz/DIV and set the FREQ DISPERSION VARIABLE control fully counterclockwise. Carefully rotate the SIGNAL FREQ POSITION f_0 COARSE control clockwise to position the next comb generator marker at the graticule f_0 vertical line. Set the MARKER MODULATION switch to 10 MHz and note on which side (left or right) of the comb generator marker the internal 10-MHz marker appears. Adjust the test oscillator frequency to obtain a zero-beat between the comb generator sideband and the internal 10-MHz marker. Note the test oscillator frequency (f_2).	c. $f_1 + f_2 \leq 100$ kHz if on opposite sides; $\lvert f_1 - f_2 \rvert \leq 100$ kHz if on same side.
		d. Connect the equipment as illustrated in figure 4-2, with the test oscillator tuned to 400 kHz and adjusted for minimum output level and the signal generator tuned to 160 MHz and adjusted for minimum output level. Set the FREQ DISPERSION switch to .3 MHz/DIV, rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the MARKER MODULATION switch to OFF and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the internal marker at the graticule f_0 vertical line. Increase the signal generator output level so that its amplitude is equal to that of the internal marker. Carefully adjust the signal generator frequency until a zero-beat with the internal marker is displayed. (During the remainder of this step	d. Test oscillator frequency is 500 ± 5 kHz.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
10 (Cont)		it may be necessary to readjust the signal generator frequency to maintain a zero-beat with the internal marker.) Set the signal generator for external amplitude modulation. Set the MARKER MODULATION switch to 1 MHz; a marker will appear on each side of the center frequency marker. Increase the test oscillator output level to obtain sideband products. Adjust the test oscillator frequency so that the second sideband zero-beats with the 1-MHz marker. Note the test oscillator frequency.	
11	To evaluate external marker operation	Set the BANDWIDTH switch to AUTO, set the FREQ DISPERSION switch to 1 MHz/DIV, set the FREQ DISPERSION VARIABLE control fully clockwise to CAL, set the SWEEP switch to 10 MS/DIV and set the MARKER MODULATION switch to EXT. Connect an HP 651B Test Oscillator, tuned to 1 MHz and adjusted for minimum output level, as illustrated in figure 4-3. Increase the test oscillator output level to obtain markers.	1-MHz markers displayed.
12	To evaluate i-f bandwidth.	a. Disconnect the equipment from the setup of figure 4-3. Set the MARKER MODULATION switch to OFF, set the AMPLITUDE SCALE switch to LIN and set the IF GAIN control fully counterclockwise. Set the FREQ DISPERSION switch to 1 kHz/DIV and, if necessary, adjust the V POS screwdriver control to position the trace on the lowest graticule horizontal line. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the marker at the graticule f_o vertical line. Set the BANDWIDTH switch to 1 kHz and adjust the MARKER LEVEL and/or IF GAIN control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the displayed pip at the LIN scale 0.7 point.	a. Pip width is 1 division wide, nominal.
		b. Set the BANDWIDTH switch to 3 kHz and adjust the MARKER LEVEL control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the displayed pip at the LIN scale 0.7 point.	b. Pip width is 3 divisions wide, nominal.
		c. Repeat step b for BANDWIDTH switch and FREQ DISPERSION switch settings listed below. BANDWIDTH Switch Setting / FREQ DISPERSION Switch Setting 10 kHz / 3 kHz/DIV 30 kHz / 10 kHz/DIV 100 kHz / 30 kHz/DIV 1000 kHz / .3 MHz/DIV	c. Nominal pip width is: 3-1/3 divisions wide 3 divisions wide 3-1/3 divisions wide 3-1/3 divisions wide

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
12 (Cont)		d. Set the BANDWIDTH switch to VAR, rotate the BANDWIDTH VARIABLE control fully clockwise, set the FREQ DISPERSION switch to 30 kHz/DIV and adjust the MARKER LEVEL and/or IF GAIN control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the display at the LIN scale 0.7 point.	d. Pip width is 3-1/3 divisions wide, nominal.
		e. Rotate the BANDWIDTH VARIABLE control counterclockwise and observe the effect on the display.	e. Pip width decreases.
13	To evaluate automatic optimum bandwidth selection.	Set the BANDWIDTH switch to AUTO, rotate the the BANDWIDTH VARIABLE control fully clockwise, set the FREQ DISPERSION switch to 1 kHz and adjust the MARKER LEVEL and/or IF GAIN control to obtain a pip peak coincident with the LIN scale 1.0 line. Note the width of the display at the LIN scale 0.7 point. Rotate the FREQ DISPERSION switch clockwise, in one-step increments (while maintaining the marker pip peak coincident with the LIN scale 1.0 line) and observe the effect on the width of the display at the LIN scale 0.7 point.	Width of pip decreases (except when switching dispersions between 10 kHz/DIV and 30 kHz/DIV, between .1 MHz/DIV and .3 MHz/DIV and between 1 MHz/DIV and 3 MHz/DIV.
14	To evaluate video filtering.	a. Rotate the MARKER LEVEL control fully counterclockwise to OFF, set the BANDWIDTH switch to 100 kHz, set the AMPLITUDE SCALE switch to LOG, set the BANDWIDTH VARIABLE control fully clockwise and adjust the IF GAIN control to obtain a noise display one box high.	
		b. Rotate the BANDWIDTH VARIABLE control slowly clockwise and note the effect on the display.	b. Noise display is smoothed.
15	To evaluate sweep speeds.	a. Connect the equipment as illustrated in figure 4-4. Adjust the attenuators for 0-dB insertion. Set the time-mark generator for pulses at a 10-microsecond interval. Set the SWEEP switch to 10 uS/DIV, set the SWEEP/SYNC switch to INT SYNC (red), set the BANDWIDTH switch to 100 kHz and rotate the IF GAIN control fully counterclockwise. Determine the time for one sweep.	a. Sweep time is nominally 100 microseconds.
		b. Rotate the SWEEP VARIABLE control fully counterclockwise and determine the time for one sweep.	b. Sweep time is nominally 300 microseconds.
		c. Set the SWEEP VARIABLE control fully cloclwise to CAL, set the SWEEP switch to 30 uS/DIV, set the time-mark generator for pulses at a 50-microsecond interval and determine the time for one sweep.	c. Sweep time is nominally 300 microseconds.
		d. Repeat step b.	d. Sweep time is nominally 1 millisecond.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
15 (Cont)		e. Repeat step b for SWEEP switch setting, SWEEP VARIABLE control setting and time-mark generator pulse intervals listed below. (1) 100 uS/DIV, Fully cw (CAL), 100 us (2) 100 uS/DIV, Fully ccw, 100 us (3) 300 uS/DIV, Fully cw (CAL), 500 us (4) 300 uS/DIV, Fully ccw, 500 us (5) 1000 uS/DIV, Fully cw (CAL), 1 ms (6) 1000 uS/DIV, Fully ccw, 1 ms (7) 3 MS/DIV, Fully cw (CAL), 5 ms (8) 3 MS/DIV, Fully ccw, 5 ms (9) 10 MS/DIV, Fully cw (CAL), 10 ms (10) 10 MS/DIV, Fully ccw, 10 ms (11) 30 MS/DIV, Fully cw (CAL), 50 ms (12) 30 MS/DIV, Fully ccw, 50 ms (13) 100 MS/DIV, Fully cw (CAL), 100 ms (14) 100 MS/DIV, Fully ccw, 100 ms (15) 300 MS/DIV, Fully cw (CAL), 500 ms (16) 300 MS/DIV, Fully ccw, 500 ms (17) 1000 MS/DIV, Fully cw (CAL), 1 second (18) 1000 MS/DIV, Fully ccw, 1 second (SWEEP Switch Setting / SWEEP VARIABLE Control Setting / Pulse Interval)	e. Nominal sweep times are: (1) 1 millisecond (2) 3 milliseconds (minimum) (3) 3 milliseconds (4) 10 milliseconds (minimum) (5) 10 milliseconds (6) 30 milliseconds (minimum) (7) 30 milliseconds (8) 100 milliseconds (minimum) (9) 100 milliseconds (10) 300 milliseconds (minimum) (11) 300 milliseconds (12) 1 second (minimum) (13) 1 second (14) 3 seconds (minimum) (15) 3 seconds (16) 10 seconds (minimum) (17) 10 seconds (18) 30 seconds (minimum)
16	To evaluate external synchronization.	a. Rotate the SWEEP VARIABLE control fully clockwise to CAL, set the SWEEP switch to 3 MS/DIV and set the SWEEP/SYNC switch to EXT SYNC (red). Adjust the time-mark generator for markers every 5 milliseconds and triggers every 10 milliseconds. b. Insert attenuation until the sweep ceases. Determine the trigger pulse amplitude from the oscilloscope display.	b. Trigger pulse amplitude is +3 volts or less.
17	To evaluate line synchronization.	Tune an HP 651B Test Oscillator to line frequency (60 Hz) and adjust for minimum output level. Connect the equipment as illustrated in figure 4-5 and set the SWEEP/SYNC switch to LINE USE. Fine tune the test oscillator to obtain a stable display and note the test oscillator frequency.	Display is synchronized to line frequency.
18	To evaluate external sweep operation.	Adjust the test oscillator for minimum output level and connect the equipment as illustrated in figure 4-6. Set the SWEEP/SYNC switch to EXT SWEEP and increase the test oscillator output level until the baseline occupies the full calibrated width of the graticule. Determine the test oscillator output level.	Test oscillator output level is 10 volts peak-to-peak (nominal).
19	To evaluate manual sweep operation.	a. Set the SWEEP/SYNC switch to MANUAL SWEEP and rotate the MANUAL control fully counterclockwise. Note the position of the spot on the screen.	a. Spot appears at left-hand side of screen.

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
19 (Cont)		b. Rotate the MANUAL control clockwise and observe the effect on the spot.	b. Spot moves to right as MANUAL control is rotated clockwise. Spot is blanked beyond extreme right-hand vertical graticule line.
20	To evaluate single sweep operation.	Set the SWEEP/SYNC switch to SINGLE SWEEP and momentarily depress the SINGLE pushbutton switch.	Single sweep is obtained.
21	To evaluate auxiliary horizontal and vertical outputs.	a. Connect the equipment as illustrated in figure 4-7. Set the SWEEP/SYNC switch to INT SWEEP, set the SWEEP TIME switch to 30 MS/DIV, set the AMPLITUDE SCALE switch to LIN and rotate the IF GAIN control fully counterclockwise. Adjust the MARKER LEVEL control (and IF GAIN control, if necessary) to obtain a pip peak coincident with the LOG scale 0 DB line. b. Determine the horizontal output voltage. c. Determine the vertical output voltage.	 b. Horizontal output voltage varies between -0.5 and +0.5 volts (nominal). c. Vertical output voltage varies between 0 and +1 volt (nominal).
22	To evaluate predetected 60-MHz output.	a. Tune an HP 608C Signal Generator to 160 MHz and adjust for minimum output level. Connect the equipment as illustrated in figure 4-8. Set the AMPLITUDE SCALE switch to LOG, set the FREQ DISPERSION switch to 0 and rotate the IF GAIN control fully counterclockwise. Increase the signal generator output level to -45 dBm and carefully trim its frequency to obtain a maximum baseline rise. b. Note the amplitude of the oscilloscope display. c. Carefully decrease the signal generator frequency (while maintaining its output level constant) until the oscilloscope display drops off 3 dB. Note the signal generator frequency. Carefully increase the signal generator frequency (while maintaining its output level constant) until the oscilloscope again drops off 3-dB after first passing through a maximum. Note the signal generator frequency.	 c. Bandwidth of predetected 60-MHz output signal is 5 MHz (nominal).
23	To evaluate intensifier operation.	a. Disconnect the equipment from the setup of figure 4-8. Set the FREQ DISPERSION switch to .1 MHz/DIV, set the BANDWIDTH switch to AUTO, set the AMPLITUDE SCALE switch to LIN and adjust the IF GAIN control to obtain a noise display one box high. Rotate the MARKER LEVEL control clockwise from its OFF position to obtain a pip peak coincident with the LIN scale 1.0 line.	

TABLE 4-3. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
23 (Cont)		b. Rotate the INTENSIFIER control clockwise and note the effect on the display.	b. Bottom portion of display is clipped as INTENSIFIER control is rotated clockwise.

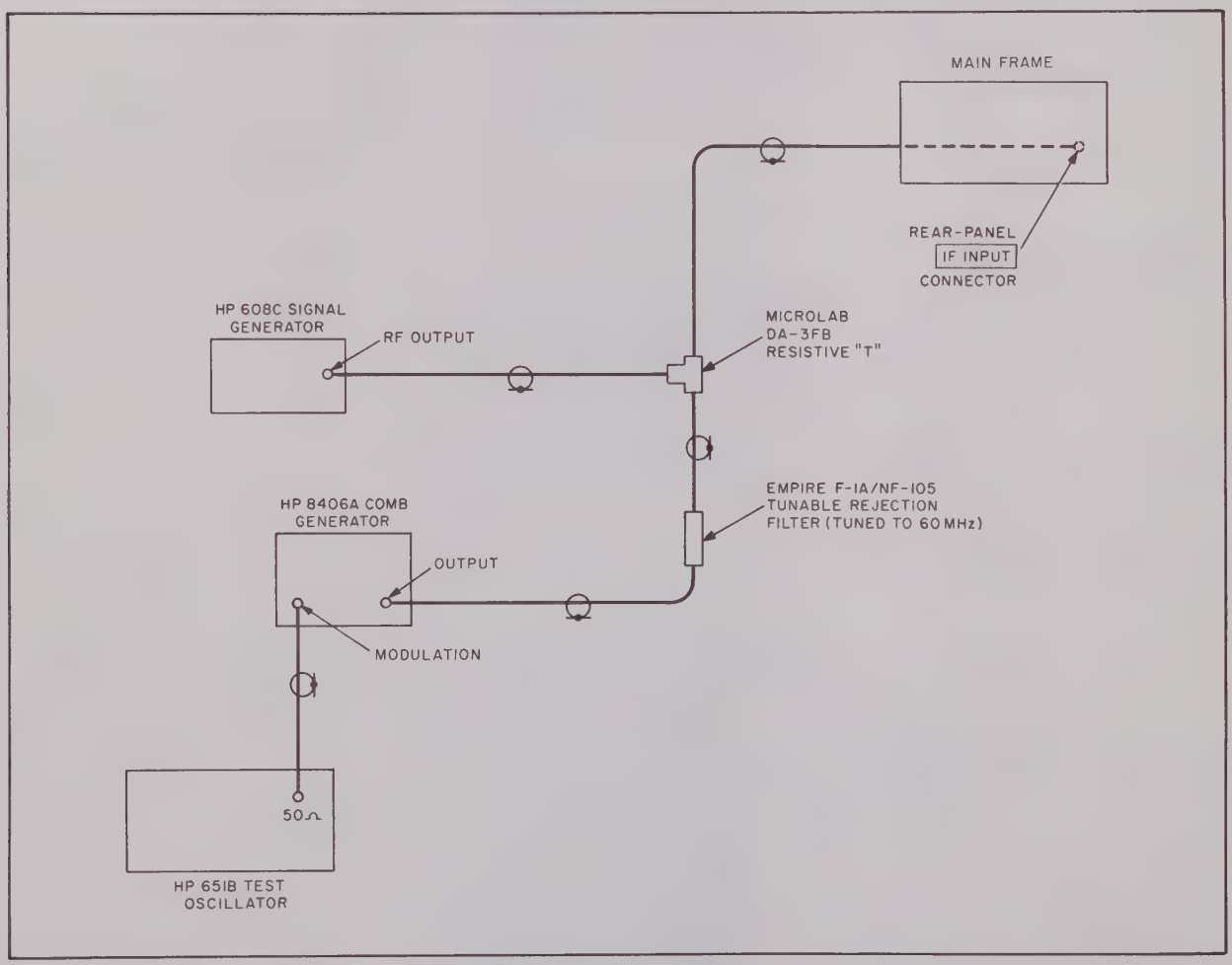


Figure 4-1. Dispersion Check Test Setup

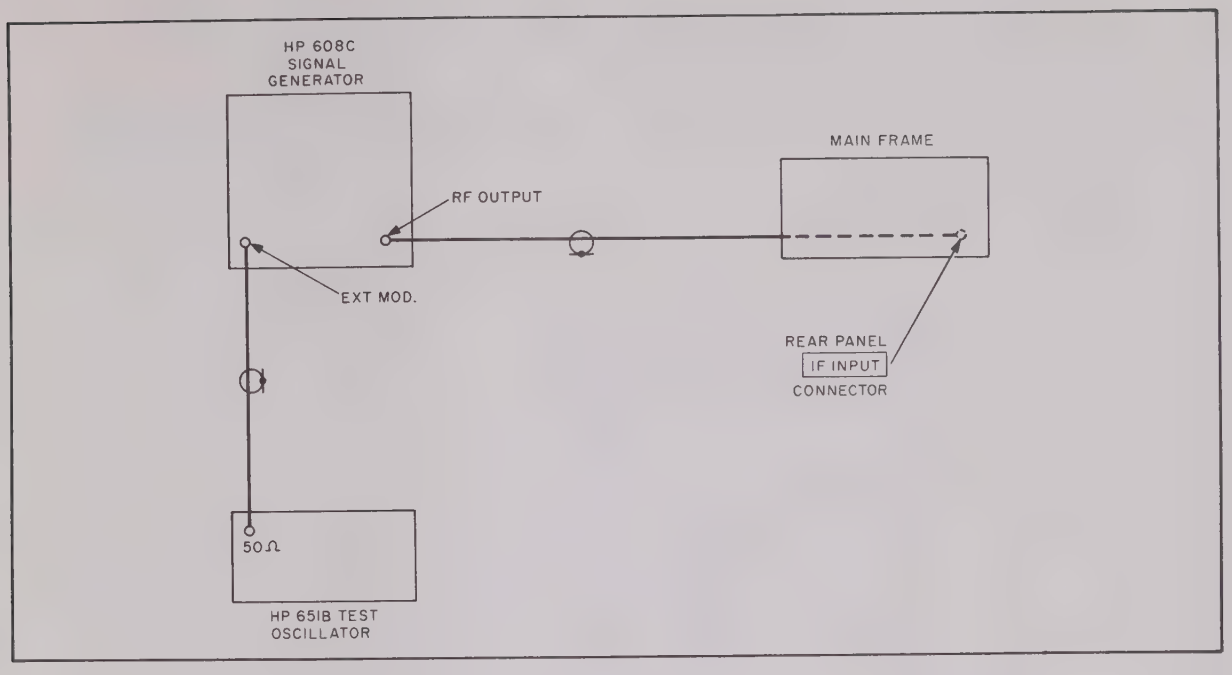


Figure 4-2. Marker Check Test Setup

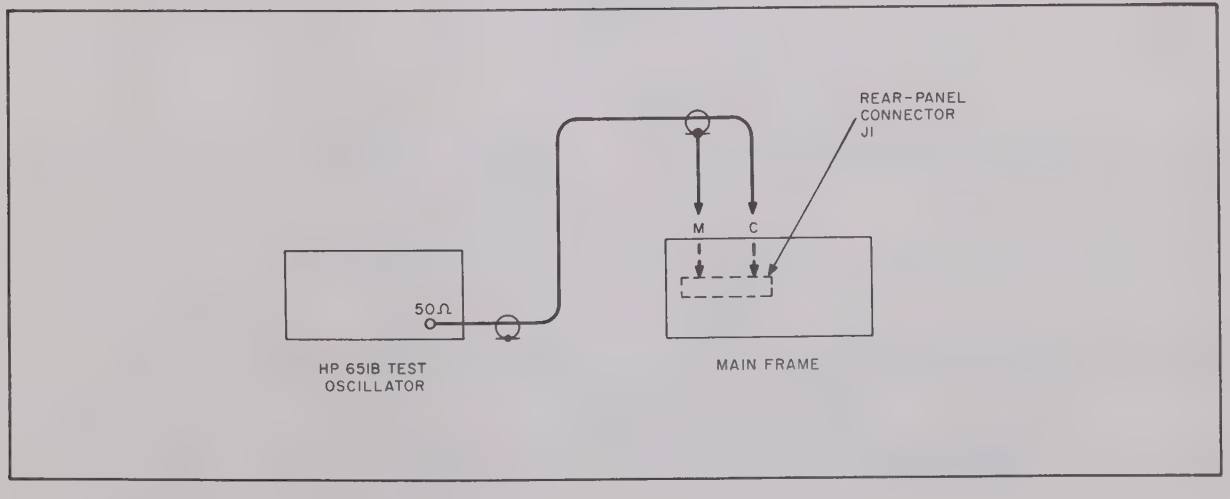


Figure 4-3. External Marker Modulation Check Test Setup

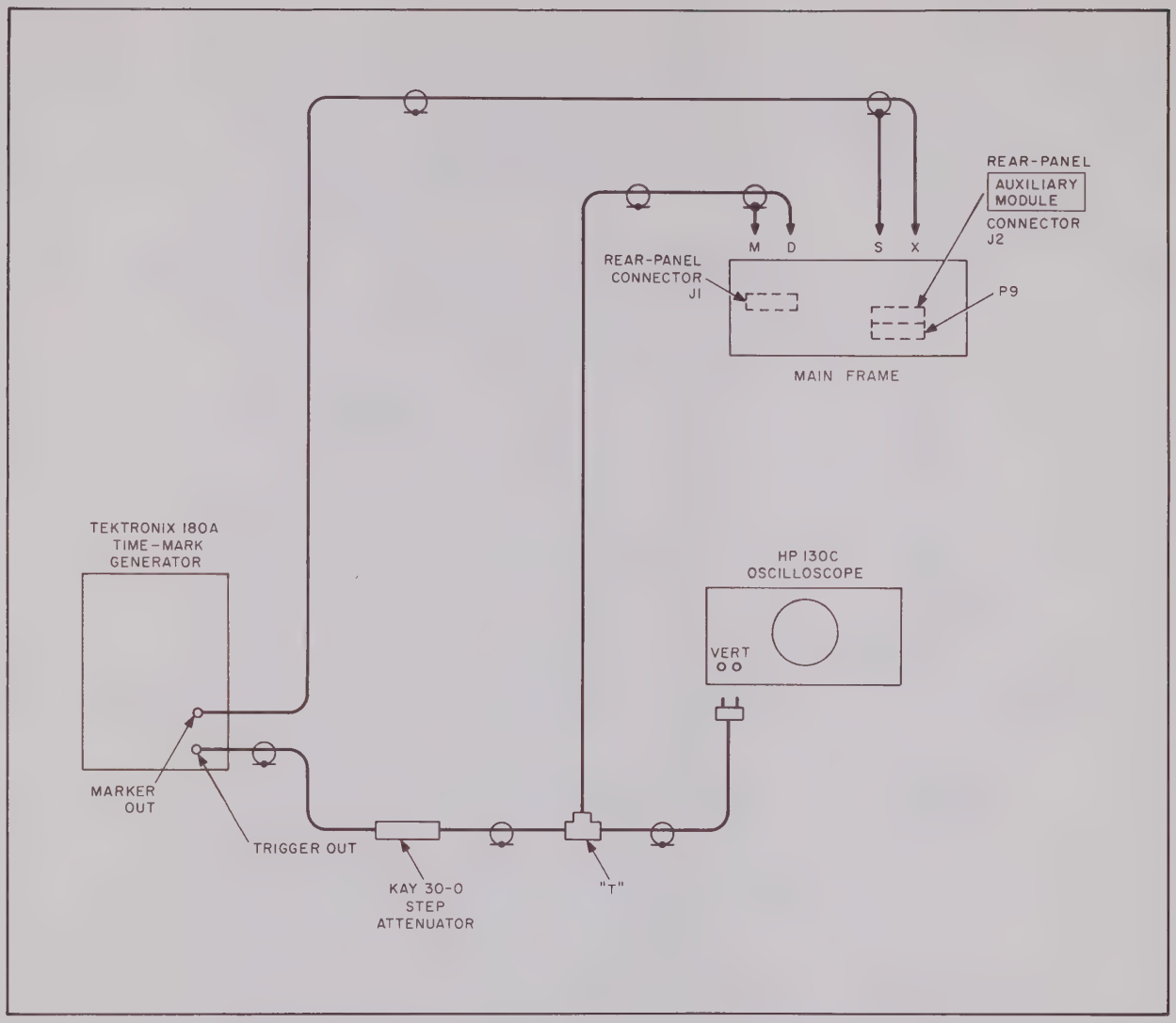


Figure 4-4. Sweep Speed Check Test Setup

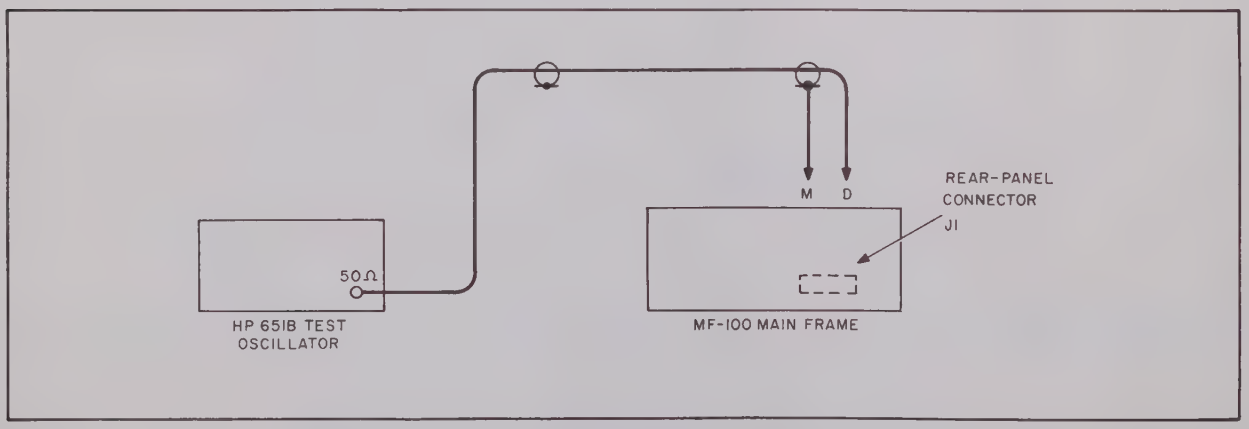


Figure 4-5. Line Synchronization Check Test Setup

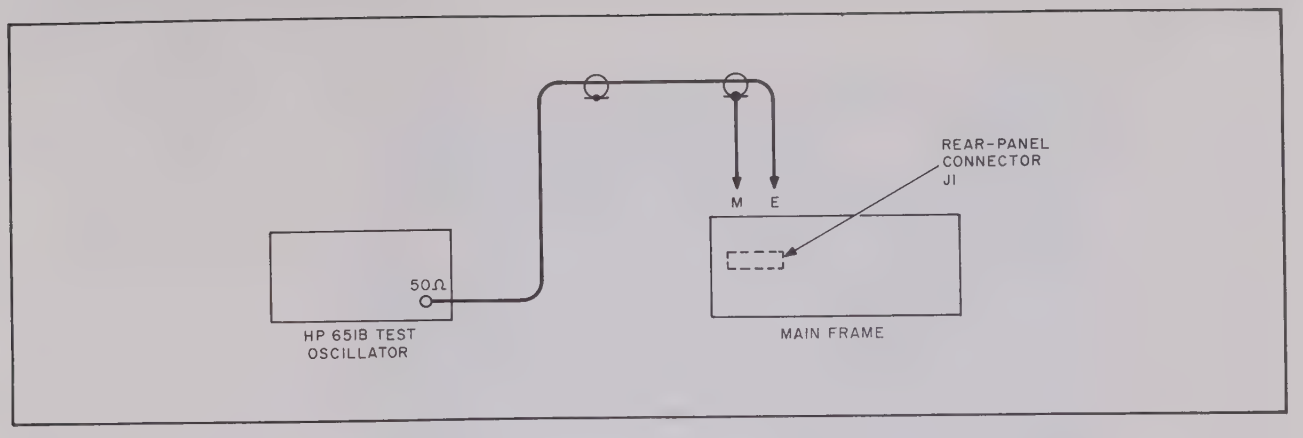


Figure 4-6. External Sweep Check Test Setup

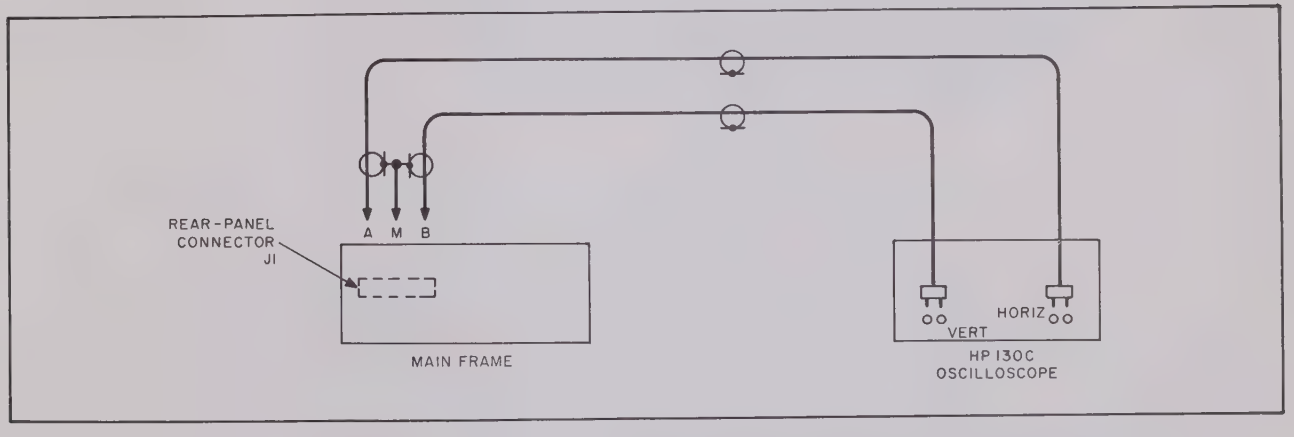


Figure 4-7. Auxiliary Horizontal and Vertical Output Check Test Setup

4-7. COMPONENT LOCATIONS.

4-8. The location of the major assemblies within the Main Frame are illustrated in figures 4-9 and 4-10. To gain access to these assemblies, remove the top and bottom dust covers as directed in paragraphs 4-9 and 4-10, respectively. To gain access to the printed circuit boards within the front and back i-f assemblies, proceed as directed in paragraph 4-11 and 4-12, respectively.

4-9. To remove the top dust cover from the Main Frame, remove the four screws (and associated hardware) that secures each side of the wraparound cover to the equipment and then carefully lift the cover away.

4-10. To remove the bottom dust cover, place the Main Frame upside-down, remove the 12 screws (and associated hardware) that secures the dust cover to the equipment and carefully lift the dust cover away.

4-11. To gain access to the printed circuit boards within front i-f assembly A2, proceed as directed in the following steps.

a. Remove the bottom dust cover as directed in paragraph 4-10.

b. Remove the 14 screws (and associated hardware) that secure the cover plate to the front i-f assembly casting.

c. Remove the cover plate; the printed circuit boards will now be visible and accessible. Refer to paragraph 4-13.

4-12. To gain access to the printed circuit boards within back i-f assembly A3, proceed as directed in the following steps.

a. Remove the top and bottom dust covers as directed in paragraphs 4-9 and 4-10, respectively.

b. Rest the Main Frame on its left side and disconnect the coaxial cables from their mating receptacles (three on the front i-f assembly and four on the back i-f assembly). Disconnect the two multipin power connectors.

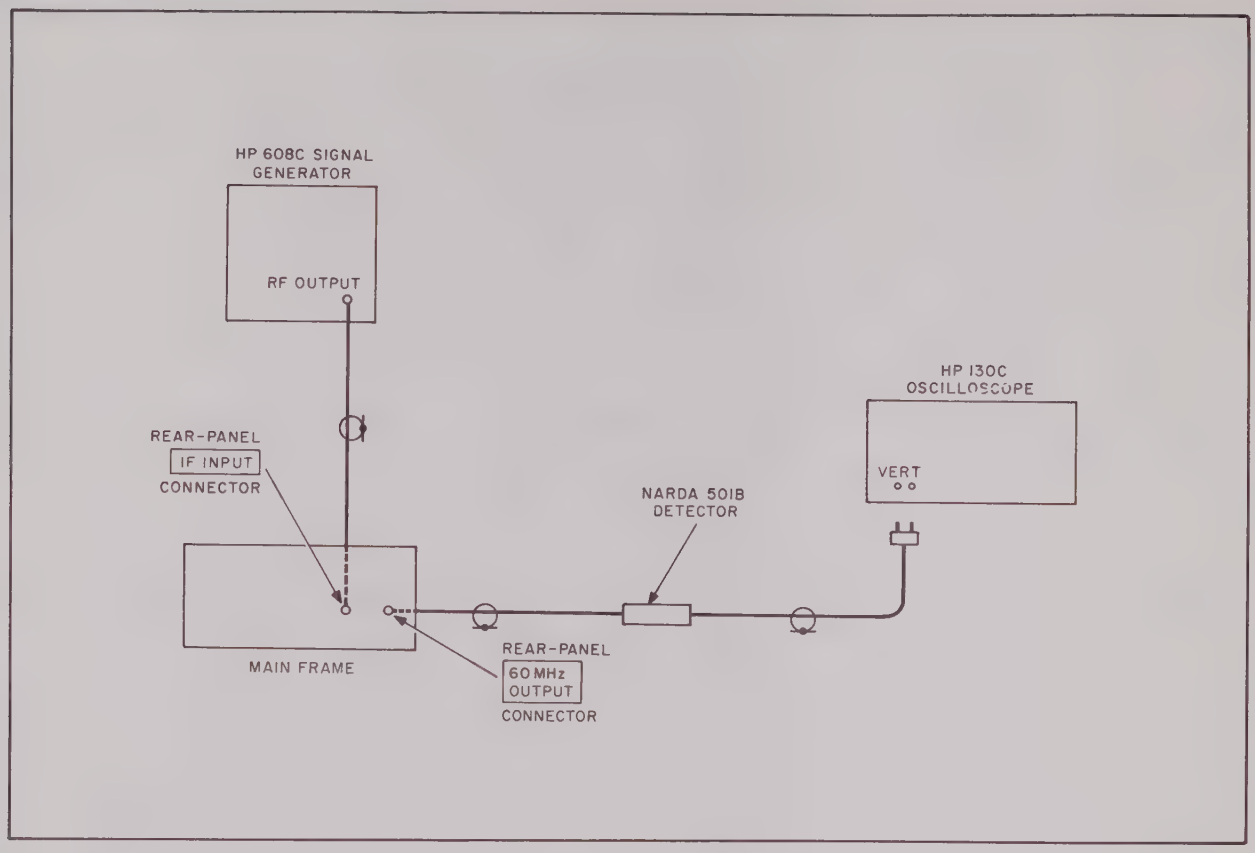


Figure 4-8. Predetected 60-MHz Output Check Test Setup

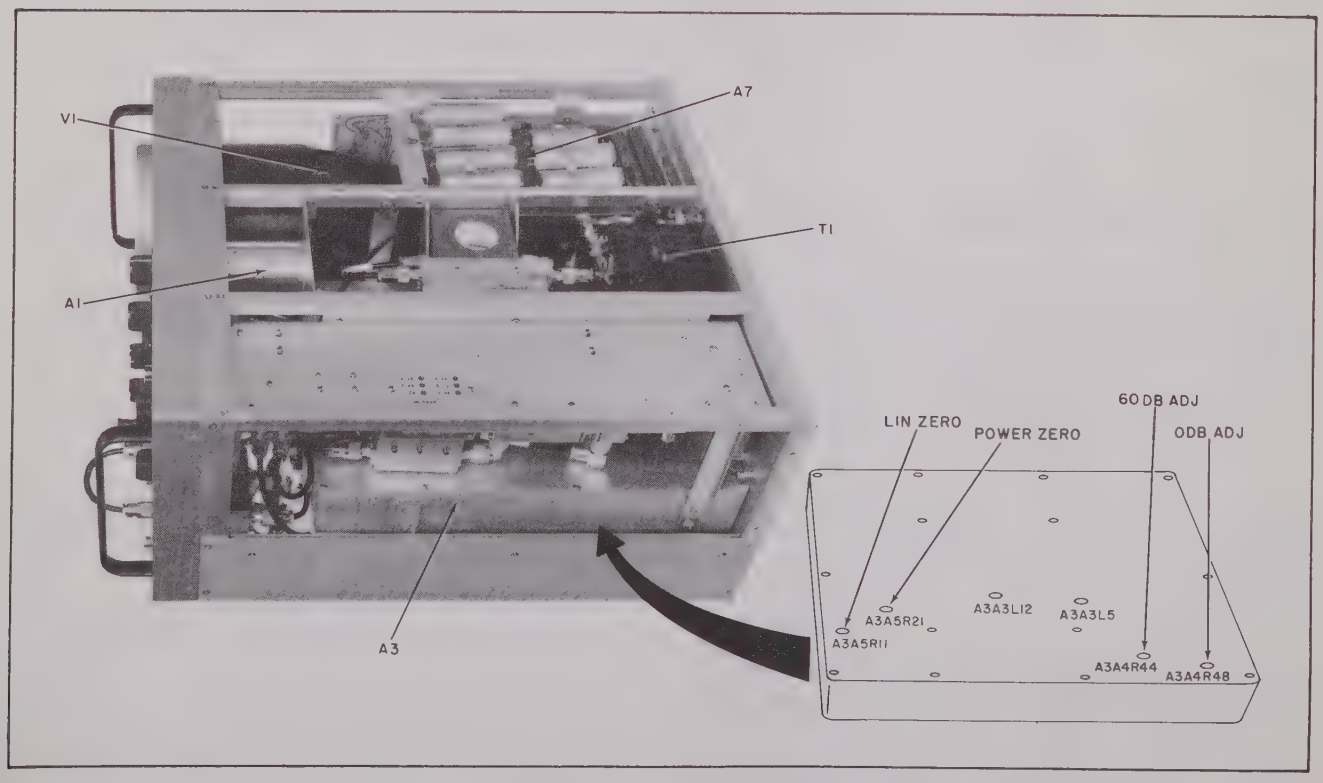


Figure 4-9. Main Frame, Top-right View

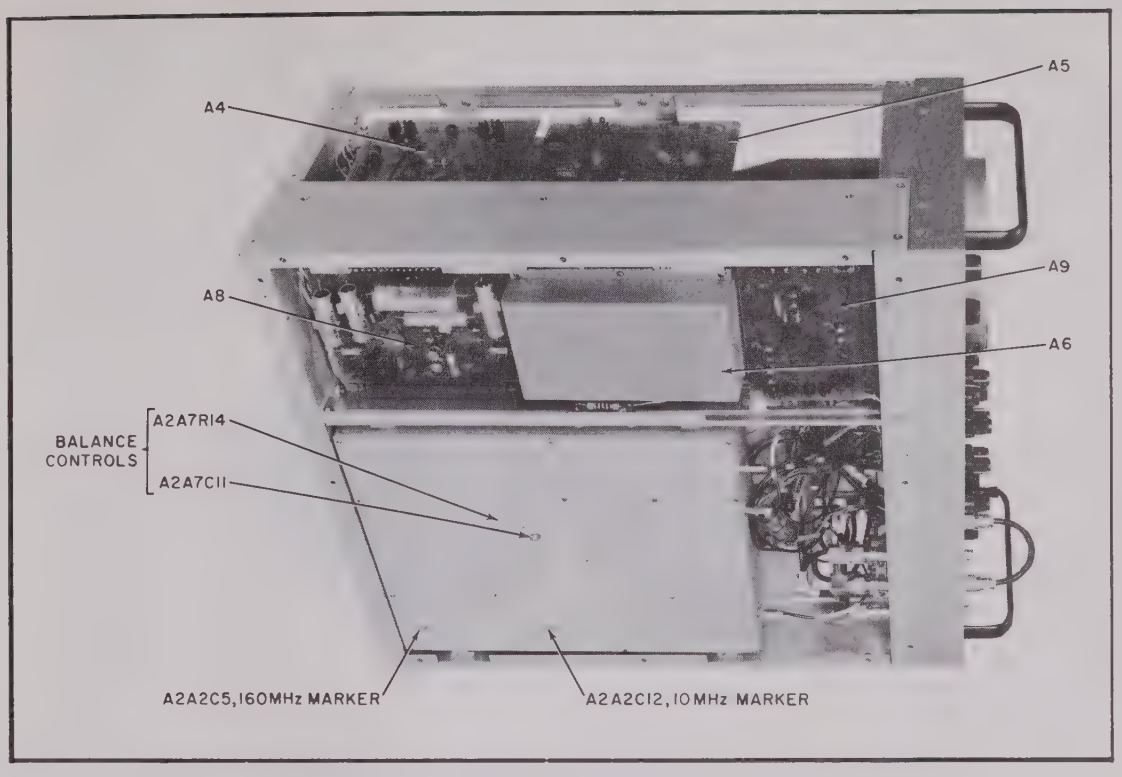


Figure 4-10. Main Frame, Bottom-left View

c. Rest the Main Frame rightside-up and remove the two bolts (and associated hardware) that secures the back i-f casting to the rear panel.

d. Turn the Main Frame upside-down and remove the four screws (and associated hardware) that secure the mounting brackets to the equipment frame.

e. Carefully place the Main Frame rightside-up and remove the three screws (and associated hardware) that secure the mounting brackets to the equipment frame.

f. Carefully lift the Main Frame up and away from the i-f assemblies. Place the Main Frame adjacent to the castings.

g. Remove the 15 screws (and associated hardware) that secure the cover plate to the back i-f assembly casting.

h. Remove the cover plate; the printed circuit boards will now be visible and accessible. Refer to paragraph 4-13.

Note

It is not necessary to separate the back and front i-f assemblies for alignment, repair and/or replacement of a printed circuit board. These assemblies should be separated only when repairing power supply wiring.

i. Place the castings on the Main Frame (see figure 4-11) and connect all coaxial and power connectors to their mating receptacles.

4-13. To gain access to the underside of any printed circuit board on either the front or back i-f assembly, proceed as directed in the following steps.

a. Disconnect all coaxial connectors from the printed circuit board to be removed.

b. Remove the four or six screws (and associated hardware) that secure the printed circuit board to the casting.

c. Carefully lift the board until the multipin connector or connectors on the underside of the board are accessible. Carefully disengage the connector(s), observing utmost care not to rotate them through 180-degrees.

4-14. POWER SUPPLY TROUBLE LOCALIZATION.

4-15. Improper operation of the Main Frame may be due to a malfunction within the power supplies. To ascertain that these supplies are operating properly, or to localize a malfunction, proceed as directed in table 4-4.

WARNING

Voltages dangerous to human life exist within the Main Frame. Observe extreme caution at all times when measuring power supply voltages.

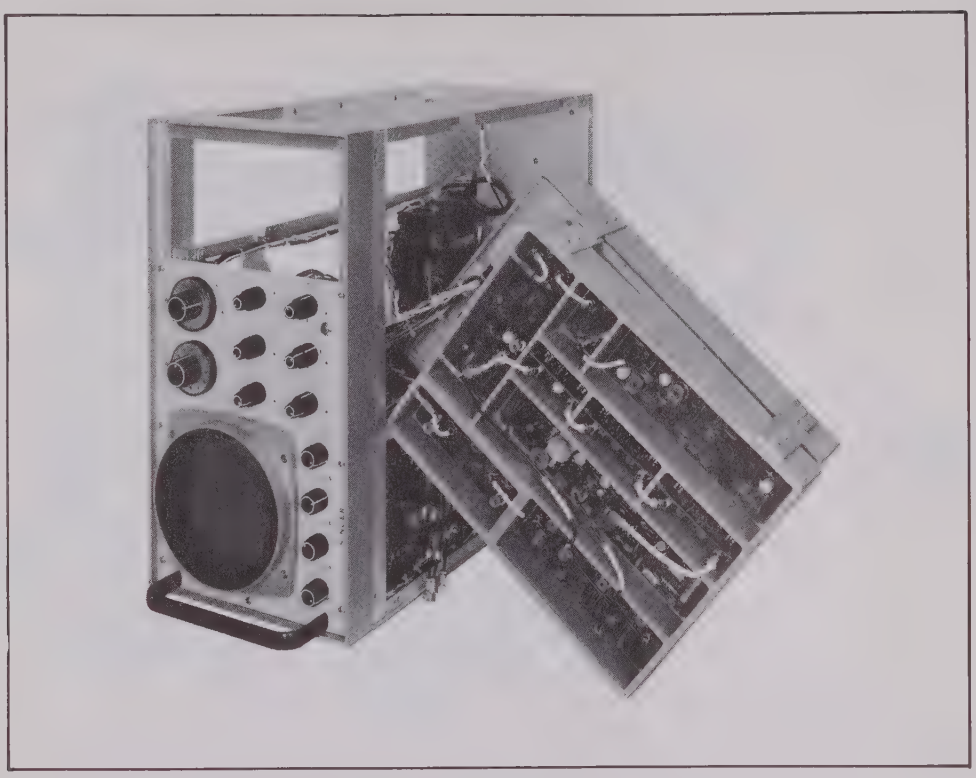


Figure 4-11. Placement of Equipment to Gain Access to Back I-f Assembly A3

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURES

Step		Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
Major	Minor				
1		Connect the + lead of a Simpson 260 VOM (set to the +1000 VDC range) to the rear-panel +300 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication.	VOM indicates between +285 and +315 volts.	Proceed to major step 2.	Proceed to minor step 1.
	1	Connect the + lead of the VOM (set to the 1000 VAC range) to T1-5; connect the common lead to T1-7. Note the VOM indication.	VOM indicates 510 volts rms (nominal).	Check A7CR1, A7CR2 and associated circuitry.	Replace T1.
2		Connect the + lead of the VOM (set to the +250 VDC range) to the rear-panel +100 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication	VOM indicates +100 volts	Proceed to major step 3.	Adjust A8R10 to obtain a VOM indication of +100 volts. If this indication cannot be obtained by adjustment of the control, proceed to minor step 2.
	2	Check fuse A7F1.	Fuse is continuous.	Proceed to minor step 3.	Check +100 volt line for a short to ground and correct this condition. Insert a replacement fuse.

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

Step		Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
Major	Minor				
	3	Connect the + lead of the VOM (set to the 250 VAC range) to T1-8; connect the common lead to T1-10. Note the VOM indication.	VOM indicates 180 volts rms (nominal).	Check Q5 (see table 4-7) and A8Q1, A8Q2, A8Q3, A8Q4 (see table 4-20) and associated circuitry. Check A7CR3, A7CR4 and associated circuitry.	Replace T1.
3		Connect the + lead of the VOM (set to the +50 VDC range) to the rear-panel +12 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication.	VOM indicates +12 volts.	Proceed to major step 4.	Adjust A8R19 to obtain a VOM indication of +12 volts. If this indication cannot be obtained by adjustment of the control, proceed to minor step 4.
	4	Check fuse A7F2.	Fuse is continuous.	Proceed to minor step 5.	Check +12 volt line for a short to ground and correct this condition. Insert a replacement fuse.
	5	Connect the + lead of the VOM (set to the 50 VAC range) to T1-11; connect the common lead to T1-12. Note the VOM indication.	VOM indicates 15 volts rms (nominal).	Check A7CR5 through A7CR8 and associated circuitry. Check Q1 and Q2 (see table 4-7) and A8Q5, A8Q6, A8Q7 (see table 4-20) and associated circuitry.	Replace T1.
4		Connect the + lead of the VOM (set to the -50 VDC range) to the rear-panel -12 V test jack; connect the common lead to the rear-panel GND test jack. Note the VOM indication.	VOM indicates -12 volts.	Proceed to major step 5.	Adjust A8R28 to obtain a VOM indication of -12 volts. If this indication cannot be obtained by adjustment of the control, proceed to minor step 6.
	6	Check fuse A7F3.	Fuse is continuous.	Proceed to minor step 7.	Check -12 volt line for a short to ground and correct this condition. Insert a replacement fuse.
	7	Connect the + lead of the VOM (set to the 50 VAC range) to T1-13; connect the common lead to T1-14. Note the VOM indication.	VOM indicates 15 volts rms (nominal).	Check A7CR9 through A7CR12 and associated circuitry. Check Q3 and Q4 (see table 4-7) and A8Q8, A8Q9, A8Q10 (see table 4-20) and associated circuitry.	Replace T1.

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

Step		Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
Major	Minor				
5		Set the SWEEP/SYNC switch to MANUAL, set the MANUAL control to mid-range, set the BRIGHTNESS control fully clockwise and rotate the INTENSIFIER control fully counterclockwise. Note the CRT display.	Spot appears on screen.	Power supplies operate properly.	Rotate A9R27 fully clockwise and replace CRT power supply A6 (refer to paragraph 4-39). Adjust A9R27 as directed in steps a through c of paragraph 4-36.

4-16. TROUBLESHOOTING PROCEDURES.

4-17. A defect within the Main Frame can be located by either symptomatic or systematic troubleshooting. The symptomatic troubleshooting procedure of table 4-5 enables the operator to localize a malfunction to a particular circuit by noting if normal operation is achieved when a front panel switch is set to one or more positions but not to others. Should operation of the front panel controls fail to produce normal operation, employ the step-by-step systematic troubleshooting procedures of table 4-6 to locate the malfunction.

4-18. ALIGNMENT PROCEDURES, FRONT I-F ASSEMBLY A2.

4-19. The procedures for aligning the various printed circuit boards within front i-f assembly A2 are detailed in paragraphs 4-20 through 4-27. Refer to paragraph 4-11 for instructions on how to gain access to these boards. Set the front panel controls as listed below prior to making any adjustments to the front i-f assembly.

Control	Setting
SCALE ILLUMINATION control	Fully cw
IF ATTENUATOR switches	00 dB
FREQ DISPERSION switch	.3 MHz/DIV
FREQ DISPERSION VARIABLE control	CAL (Fully cw)
MARKER MODULATION switch	OFF
MARKER LEVEL control	OFF (Fully ccw)
AMPLITUDE SCALE switch	LOG
SIGNAL FREQ POSITION f_0 COARSE control	Mid-range
SIGNAL FREQ POSITION f_0 FINE control	Mid-range
BANDWIDTH switch	100 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	CAL (Fully cw)
SWEEP/SYNC switch	INT SWEEP
IF GAIN control	To obtain one division of noise

4-20. MARKER OSCILLATOR A2A1. To align the marker oscillator, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Connect the equipment as illustrated in figure 4-1. Tune the signal generator for a 160-MHz cw output and set the comb generator for 10-MHz markers. Set the test oscillator for minimum output level. Adjust the comb generator output level to obtain a convenient display amplitude and identify the 160-MHz marker by means of the signal generator.

b. Center the 160-MHz marker at the graticule f_0 vertical line by means of the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control and then set the signal generator for minimum output level.

TABLE 4-5. SYMPTOMATIC TROUBLESHOOTING PROCEDURE

Symptom	Probable Cause
Internal center frequency marker cannot be obtained but 160-MHz injected at rear-panel IF INPUT connnector is displayed.	Check A2A1Q1 (see table 4-8), MARKER MODULATION switch S4 and associated circuitry.
10-MHz sidebands cannot be obtained on center frequency marker but 1-MHz sidebands can be displayed.	Check A2A1Q3 (see table 4-8) and associated circuitry.
1-MHz sidebands cannot be obtained on center frequency marker but 10-MHz sidebands can be displayed.	Check A2A1Q4 (see table 4-8) and associated circuitry.
Neither 10-MHz nor 1-MHz sidebands can be obtained on center frequency marker but external marker modulation is displayed.	Check A2A1Q2 (see table 4-8) and associated circuitry.
Internal center frequency marker cannot be either internally or externally modulated.	Check A2A1CR1 through A2A1CR4 and associated circuitry.
Marker level cannot be adjusted.	Check MARKER LEVEL control R21/S8 and associated circuitry.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to LIN; vertical display normal in LOG and PWR.	Check A3A5Q2, A3A5Q3 (see table 4-17) and associated circuitry.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to PWR; vertical display normal in LIN and LOG.	Check A3A5Q4 through A3A5Q7 (see table 4-17) and associated circuitry.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to LOG, LIN or POWER.	Refer to table 4-6.
Horizontal trace present. No vertical display when AMPLITUDE SCALE switch set to LIN or PWR; vertical display normal in LOG.	Check A3A5Q1 (see table 4-19) and associated circuitry.
Horizontal trace present. No vertical display when BANDWIDTH switch set to 1000 kHz; vertical display present for all other settings of switch.	Check A3A1Q1 (see table 4-13), A3A1CR1, A3A1CR2, A3A3CR1, A3A3CR2 and associated circuitry.
Horizontal trace present. No vertical display when BANDWIDTH switch set to any position other than 1000 kHz.	Check A3A2 (see table 4-14), A3A3 (see table 4-15), diodes A3A1CR3 and A3A1CR4 and associated circuitry.
Horizontal trace present. No vertical display when FREQ DISPERSION switch set to 10, 3 or 1 MHz/DIV; vertical display normal for all other switch settings.	Check A2A7Q1, A2A7Q2, A2A7Q3 (see table 4-10) and associated circuitry.
Horizontal trace present. No vertical display when FREQ DISPERSION switch set to .3 MHz/DIV, .1 MHz/DIV, 10, 3, 1 or 0 kHz/DIV; vertical display normal for all other switch settings.	Check A2A7Q5, A2A7Q6, A2A7Q7 (see table 4-10) and associated circuitry.
Sweep cannot be initiated by operation of SINGLE pushbutton switch S10 when SWEEP/SYNC switch S3 is set to SINGLE, and all other sweep modes are operational.	Check the contacts of SWEEP SYNC switch S3 and SINGLE pushbutton switch S10; also check associated resistors R27 and R28, along with capacitor C4.

TABLE 4-5. SYMPTOMATIC TROUBLESHOOTING PROCEDURE (Cont'd)

Symptom	Probable Cause
Sweep cannot be initiated in the sync modes of operation, i.e., SWEEP/SYNC switch S3 is set to either CAL, USE, INT, EXT; but all other modes are operational.	Check A5Q34/Q35, A5Q36/Q37, A5Q26, A5Q27, A5Q19 (see table 4-19 and associated circuitry.
In analyzer operation only, SWEEP switch S2B set to any MS/DIV position, sweep is erratic; but in the synchroscope mode, the set is operational.	Check timing switch A5Q40 (table 4-19) and associated circuitry.
No sweep in any mode of operation except MAN and EXT.	Refer to Systematic Troubleshooting Procedure Table 4-6.
No sweep at all in any mode of operation.	Check A5Q29/Q30 (see table 4-19); A4Q10, A4Q11, A4Q12 (see table 4-18); the CRT and associated circuitry.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING PROCEDURE

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
		Note Steps 1 through 9 provide procedures for troubleshooting the equipment when a trace is present with no vertical deflection.		
1	Set SWEEP/SYNC switch S3 to CAL	Full-scale LOG deflection of the trace on the Main Frame CRT display.	Proceed to step 2.	Check V POS potentiometer R7; a dc potential should be present on pin 12 of deflection amplifier assembly A4. Using a dc meter, check the contacts of relay K1 for continuity. If no fault is uncovered, check deflection amplifier assembly A4. Refer to table 4-18.
2	Remove plug P2 from jack J2 of back i-f assembly A3; connect a Hewlett Packard Model 606B signal generator to jack J2 of the assembly and apply a -24 dBm 6.5 MHz signal. Adjust the signal generator output frequency for maximum deflection of the trace.	Full-scale deflection of the trace on Main Frame CRT display.	Proceed to step 5.	Proceed to step 3.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING PROCEDURE (Cont'd)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
3	Gain access to back i-f assembly A3. Remove plug P2 from jack J1 of log amplifier assembly A3A4. Connect the signal generator to jack J1 of the assembly and apply a -10 dBm 6.5 MHz signal.	Full-scale deflection of the trace on Main Frame CRT display.	Refer to table 4-5.	Disconnect the signal generator and reconnect the cables. Proceed to step 4.
4	Remove plug P2 from jack J1 of Lin Power scale assembly A3A5. Connect the signal generator to jack J1 of the assembly and apply a +5 dBm 6.5 MHz signal.	Full-scale LIN deflection of the Main Frame CRT display.	Check log amplifier assembly A4 in accordance with table 4-16.	Refer to table 4-5 and check associated circuitry including resistor R51.
5	Restore all loosened cables of back i-f assembly A3, and gain access to the internal circuits of front i-f assembly A2 using the procedures of paragraph 4-11. Remove plug P2 from jack J1 of 60-6.5 MHz converter assembly A2A9. Connect the signal generator to jack J1 of the assembly and apply a -20 dBm 60 MHz signal. Adjust the signal generator output frequency for maximum deflection of the trace.	Full scale LOG deflection of the trace on the Main Frame CRT display.	Disconnect the signal generator and reconnect the cable to assembly A2A9.	Check 60-6.5 MHz converter assembly A2A9 in accordance with table 4-12.
6	Remove plug P2 from jack J1 of 60 MHz amplifier assembly A2A8. Connect a Hewlett Packard Model 608C to jack J1 of the assembly and apply a -40 dBm 60 MHz signal. **Note** The -40 dBm signal is nominal for normal operating conditions; if the IF GAIN is reduced to minimum, a -23 dBm signal is required. If the IF GAIN adjust is set to maximum a -53 dBm signal is required.	Full-scale LOG deflection of the trace on the Main Frame CRT display.	Disconnect the signal generator and reconnect the cable to assembly A2A8.	Check 60 MHz amplifier assembly A2A8 in accordance with table 4-11.
7	Remove plug P2 from jack J1 of wideband and narrow band swept oscillator assembly A2A7. Connect the signal generator to jack J1 of the assembly and check the sensitivity in accordance with the minimum performance tests.	The sensitivity should be better than -105 dBm.	Disconnect the signal generator and reconnect the cable to assembly A2A7.	Check wideband and narrow band swept oscillator assembly A2A7 in accordance with table 4-10.
8	Remove plug P2 from jack J1 of high pass filter assembly A2A4. Connect the signal generator to jack J1 of the assembly and check the sensitivity as in step 7.	The sensitivity should be better than -93 dBm.	Disconnect the signal generator and reconnect the cable to assembly A2A4. Perform step 9.	Check filter assemblies A2A4, A2A5 and A2A6.
9	Remove plug P2 from jack J2 of 160 MHz wideband amplifier assembly A2A3. Connect the signal generator to jack J2 of the assembly and check the sensitivity as in step 7.	The sensitivity should be better than -110 dBm.	Check i-f attenuator assembly A1.	Check 110 MHz wideband amplifier assembly A2A3 in accordance with table 4-9.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING PROCEDURE (Cont'd)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
		Note Steps 10 and 11 provide troubleshooting procedures covering the sweep control circuit.		
10	With SWEEP switch S2 set to any MS/DIV position, and SWEEP SYNC switch S3 set to MAN, set MANUAL SWEEP potentiometer R26 fully counterclockwise and check the output levels of the sweep control circuitry.	Stage / Output Indication: Q31/Q32 0 Q33 1 Q26 0 Q21 0 Q19 0 Q20 1 Q11 0* Q27 0 Q28 0 Q38/Q39 1 Q25 0 Q22 0 Q23 1 Q24 0 Q12 1* * 1 and 0 indications for Q11 and Q12 are 12 volts and 6 volts, respectively; for all others 1 and 0 are nominally 8 volts and 0 volt.	Proceed to step 11.	Check stages in order of table, and repair stage providing faulty output indication.
11	With SWEEP switch S2 set to any MS/DIV position and SWEEP SYNC switch S3 set to MAN, adjust MANUAL SWEEP potentiometer R26 until Schmitt trigger A5Q31/Q32 trips.	A5Q31/Q32 should trip when the input potential reaches 5 volts, at which time the dot should be blanked. Stage / Output Indication: Q31/Q32 1 Q33 0 Q26 0 Q21 1 Q20 0 Q11 1* Q27 0 Q28 1 Q38/Q39 0 Q25 1 Q23 0 Q24 1 Q12 0* *1 and 0 indications for Q11 and Q12 are 12 volts and 6 volts, respectively; for all others 1 and 0 are nominally 8 volts and 0 volt.		Check stages in order of table and repair stage providing faulty output indication.

c. Rotate the MARKER LEVEL control clockwise from its OFF position and set to obtain a convenient marker display amplitude.

d. Adjust A2A1C5 so that the internal 160-MHz marker pip zero-beats with the comb generator 160-MHz marker.

e. Turn on the comb generator 1-MHz interpolation markers and set the MARKER MODULATION switch to 1 MHz.

f. Adjust A2A1C19 so that the internal 1-MHz markers zero-beat with the comb generator 1-MHz interpolation markers.

g. Turn off the comb generator 1-MHz interpolation markers, set the FREQ DISPERSION switch to 3 MHz/DIV and set the MARKER MODULATION switch to 10 MHz.

h. Adjust A2A1C15 so that the internal 10-MHz markers zero-beat with the comb generator markers.

4-21. 160-MHz WIDEBAND AMPLIFIER A2A3. To align the 160-MHz wideband amplifier, proceed as follows.

a. Connect the equipment as illustrated in figure 4-12. The sweep generator is to be tuned to a center frequency of 160 MHz, a sweepwidth of 200 MHz and an output level of approximately -20 dBm. Set the step attenuator for 0 dB insertion.

b. Adjust A2A3C18 to position the notch at exactly 100 MHz.

c. Tune A2A3L2, A2A3L3, A2A3C17 and A2A3C2 to obtain a response which is flat (within ± 1 dB) from 110 to 210 MHz.

d. Connect the equipment as illustrated in figure 4-14 and set the step attenuator for 10 dB insertion. Note the waveform displayed on the oscilloscope screen.

e. Reset the step attenuator for 0 dB insertion and connect the 20-ft cable directly to the MF-100 rear panel 160MHz IF INPUT connector and again note the waveform; it should be no greater then that noted in step d.

4-22. HIGH PASS FILTER A2A4. To align the high pass filter, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-15.

b. Tune the sweep generator to a center frequency of 160 MHz, a sweepwidth of 300 MHz and an output level of 0 dBm. Tune the signal generator to obtain a marker at 60 MHz.

c. Adjust A2A4C4 to position the notch at 60 MHz, as illustrated in figure 4-16.

4-23. LOW PASS FILTER A2A5. To align this low pass filter, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-17.

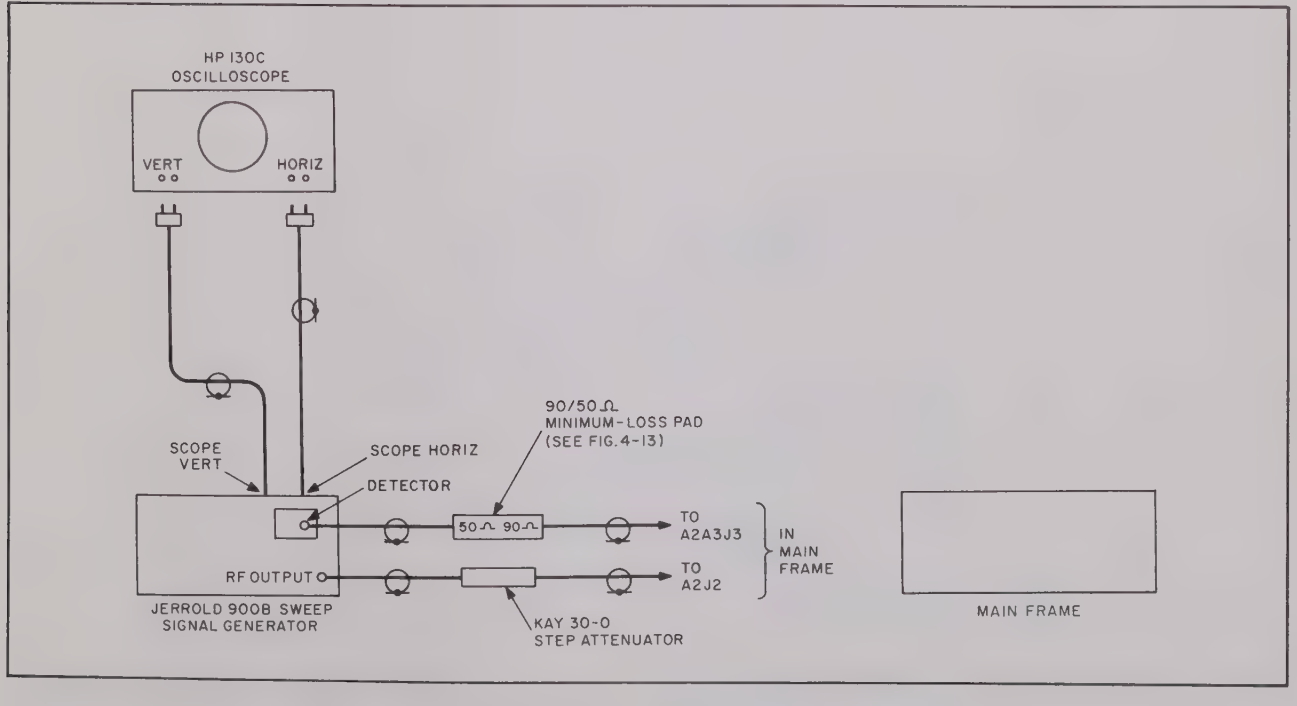


Figure 4-12. 160-MHz Wideband Amplifier A2A3 Alignment, Equipment Setup No. 1

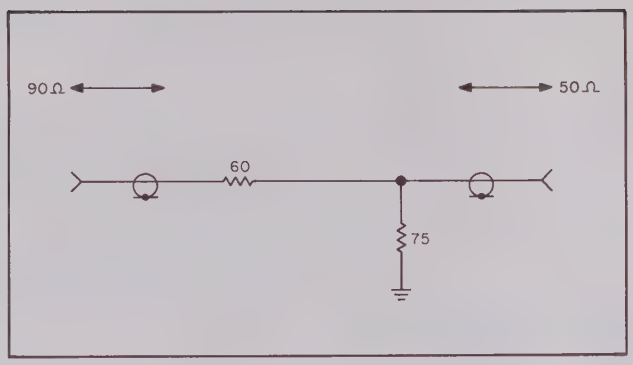


Figure 4-13. 90/50 Ohm Minimum Loss Pad, Schematic Diagram

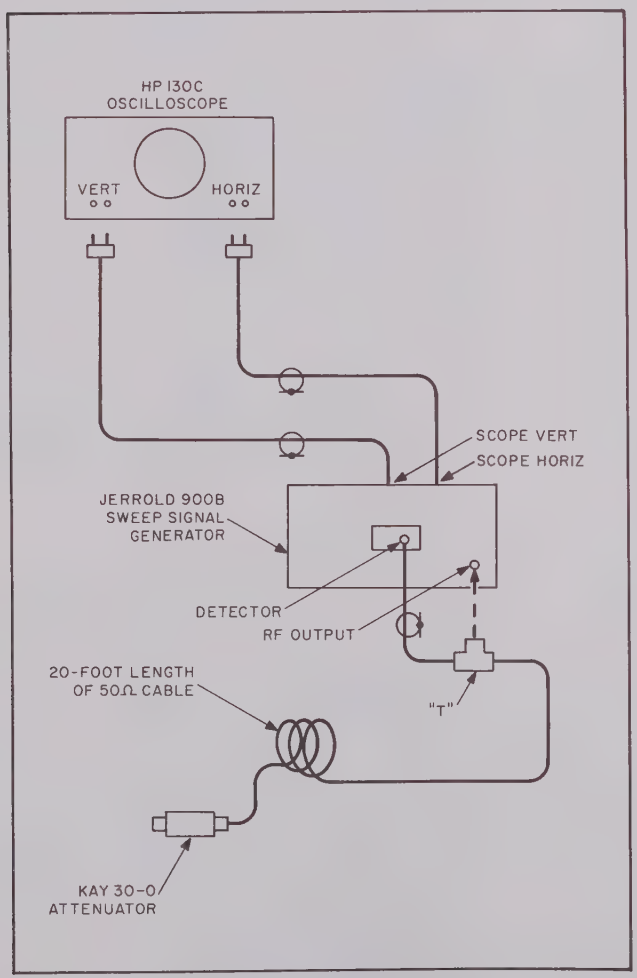


Figure 4-14. 160-MHz Wideband Amplifier A2A3 Alignment, Equipment Setup No. 2

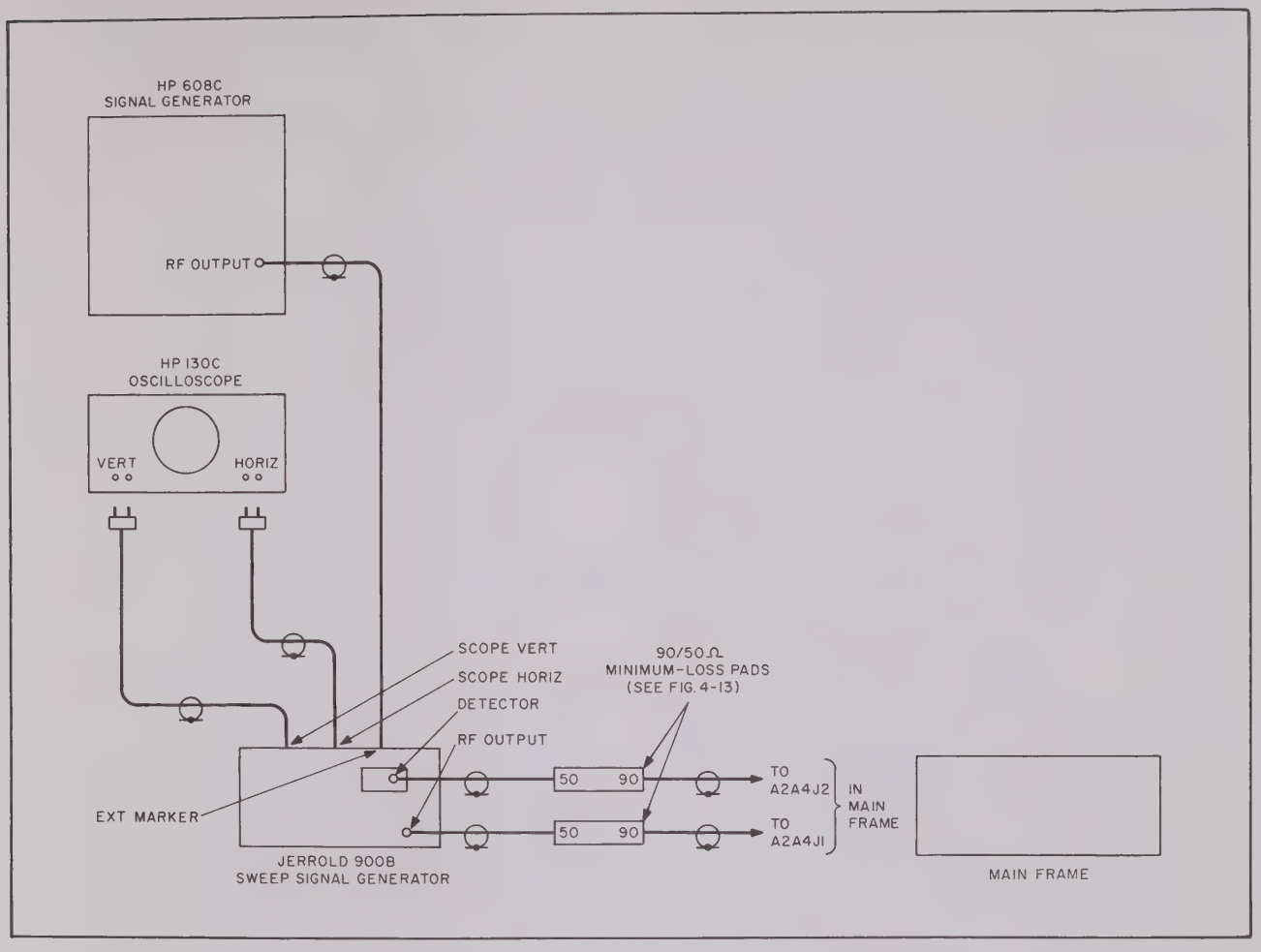


Figure 4-15. High Pass Filter A2A4 Alignment, Equipment Setup

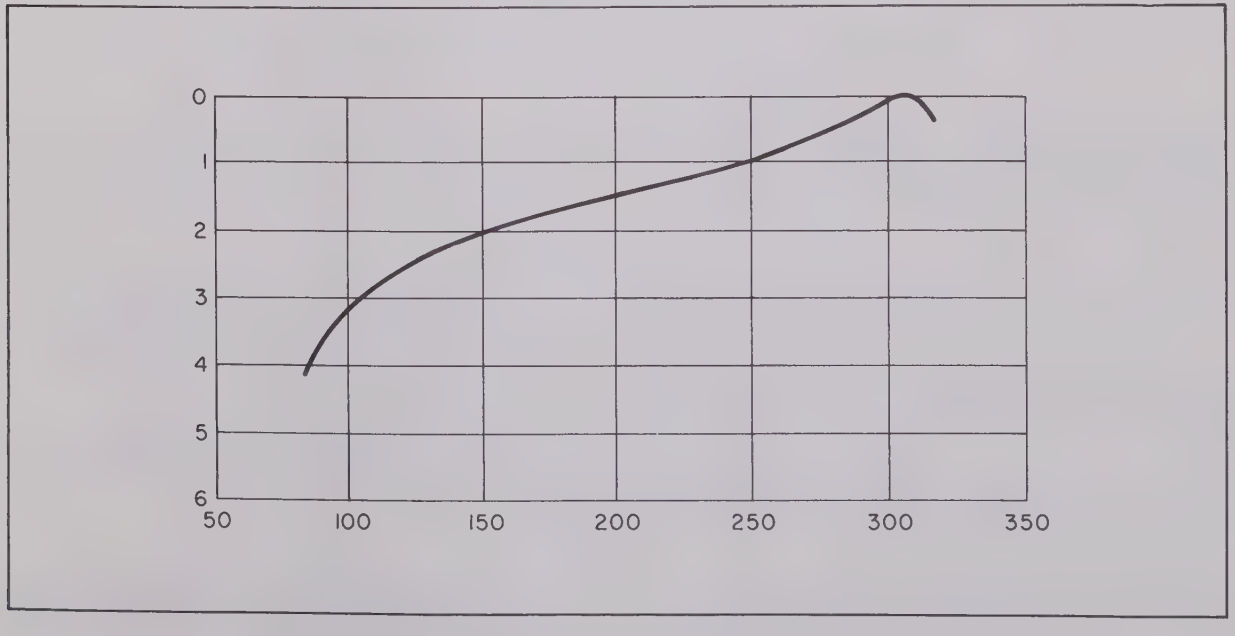


Figure 4-16. High Pass Filter A2A4 Frequency Response

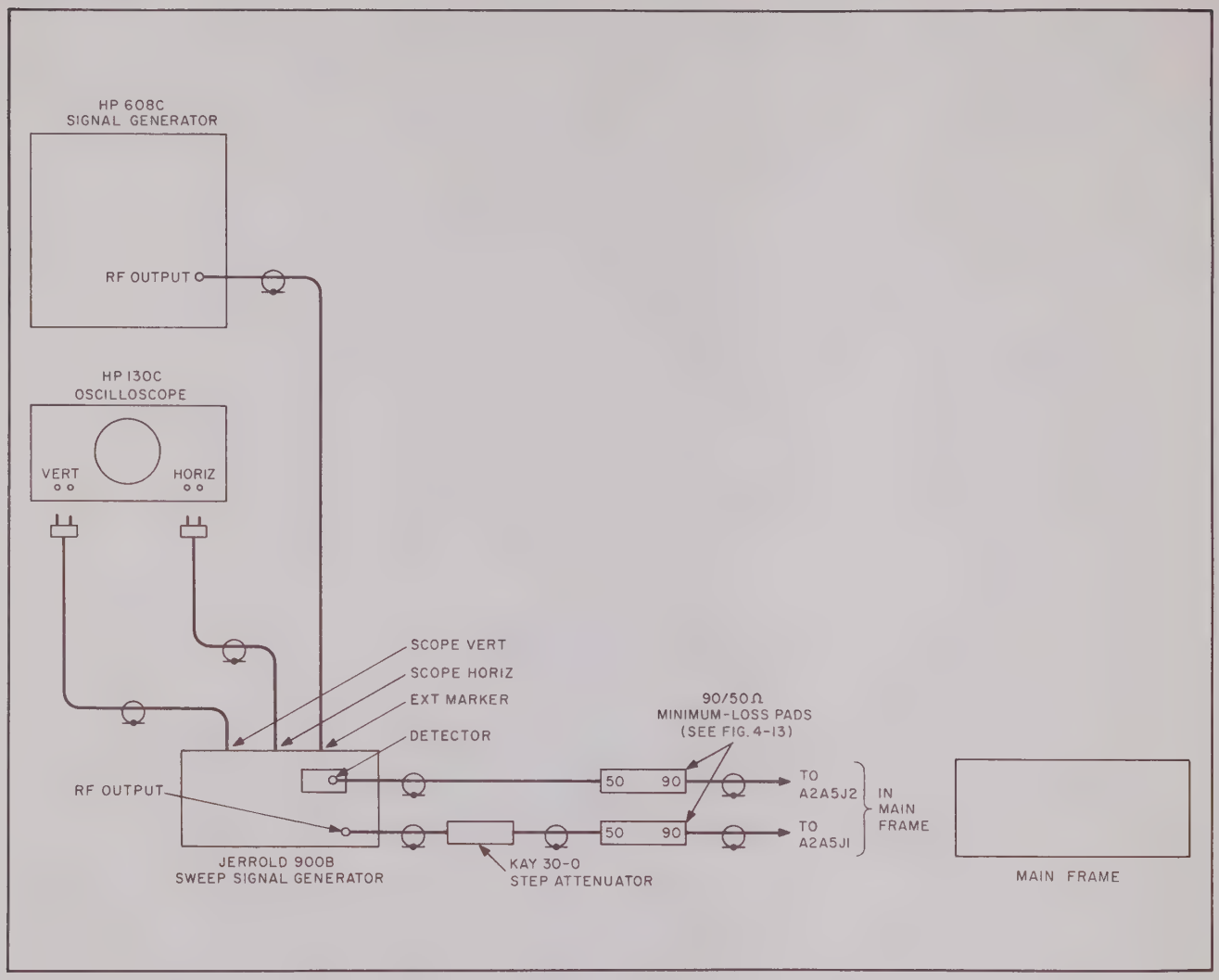


Figure 4-17. Low Pass Filter A2A5 Alignment, Equipment Setup

b. Tune the sweep generator to a center frequency of 160 MHz, a sweepwidth of 200 MHz and an output level of 0 dBm. Tune the signal generator to obtain a marker at 210 MHz. Set the attenuator for 0 dB insertion.

c. Adjust A2A5C2, A2A5C3 and A2A5C5 to obtain a response similar to that illustrated in figure 4-18.

d. Adjust the vertical gain of the oscilloscope to obtain a display of convenient amplitude. Trace the display on the oscilloscope screen with a marker pencil.

e. Disconnect the low pass filter and couple the two minimum-loss pads together by means of a short length of 90-ohm coaxial cable.

f. Insert step attenuation until the amplitude of the trace coincides with the pass band recorded in step d. The attenuation inserted should be 1 dB or less.

4-24. LOW PASS FILTER A2A6. To align this filter, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-19.

b. Tune the sweep generator to a center frequency of 160 MHz, a sweepwidth of 200 MHz and an output level of 0 dBm. Tune the signal generator to obtain a marker at 210 MHz. Set the attenuator for 0 dB insertion.

c. Adjust A2A6C2, A2A6C3 and A2A6C5 to obtain a response similar to that illustrated in figure 4-18.

d. Adjust the vertical gain of the oscilloscope to obtain a display of convenient amplitude. Trace the display on the oscilloscope screen with a marker pencil.

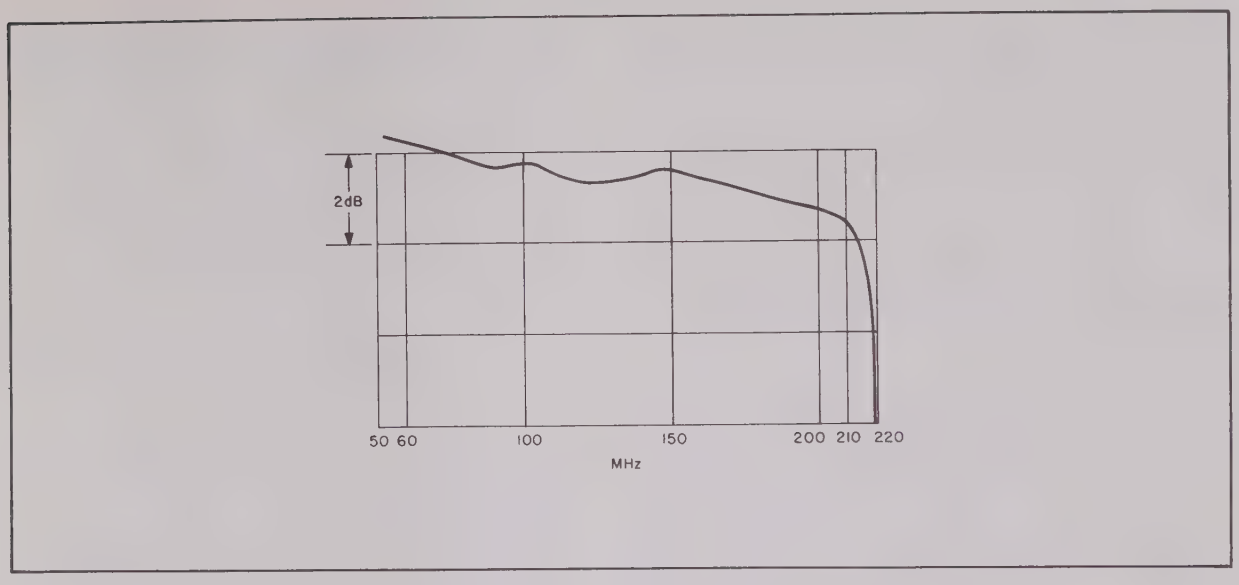


Figure 4-18. Low Pass Filters A2A5 and A2A6, Frequency Response

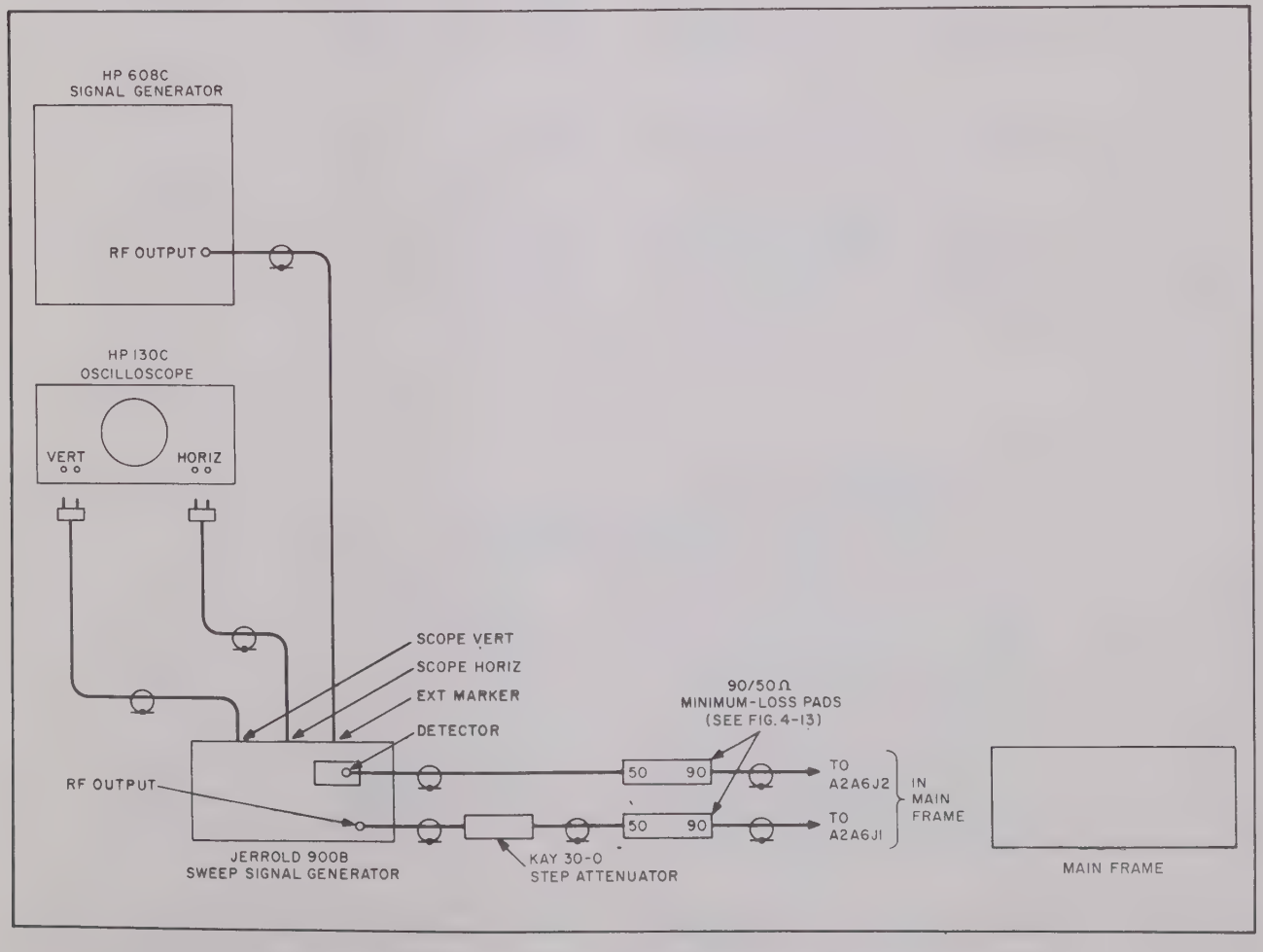


Figure 4-19. Low Pass Filter A2A6 Alignment, Equipment Setup

e. Disconnect the low pass filter and couple the two minimum-loss pads together by means of a short length of 90-ohm coaxial cable.

f. Insert step attenuation until the amplitude of the trace coincides with the pass band recorded in step d. The attenuation inserted should be 5 dB or less.

4-25. SWEPT OSCILLATOR A2A7. To align the swept oscillator, set the front panel controls as directed in paragraph 4-19 and then continue as indicated below.

a. Set the FREQ DISPERSION switch to 10 MHz/DIV and rotate the MARKER LEVEL control fully clockwise.

b. Set A9R17 and A9R18 fully clockwise.

c. Set A2A7R14 to mid-range.

d. Tune A2A7T3 to obtain a pip of maximum amplitude.

e. Rotate A2A7R9 fully clockwise and connect the equipment as illustrated in figure 4-20.

f. Set the comb generator for 10-MHz markers and adjust its output level to obtain a convenient display amplitude.

g. Adjust A2A7C8 to position the internal 160-MHz marker as far to the right side of the screen as possible (minimum capacitance).

h. Set the comb generator for both 10- and 1-MHz markers and rotate A2A7C8 counterclockwise so that the center frequency marker is 52 MHz from the graticule extreme right hand vertical line.

i. Adjust A2A7R9 for optimum linearity and reset A2A7C8 so that the center frequency marker is 52 MHz from the graticule extreme right hand vertical line.

j. Adjust A9R20 to position the internal 160-MHz marker pip coincident with the graticule f_o vertical line.

k. Adjust A9R17 to obtain a display dispersion of 100 MHz.

l. Set the FREQ DISPERSION switch to .3 MHz/DIV and adjust A9R21 to center the display on the screen.

m. Adjust A2A7R25 for optimum linearity.

n. Select that portion of the display which appears most linear and center it on the screen by adjusting A9R21.

o. Spread or compress the turns of A2A7L5 to position the internal 160-MHz marker at the graticule f_o vertical line.

p. Set the FREQ DISPERSION switch to .1 MHz/DIV and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control so that two pips appear on the screen, each pip equidistant from the graticule f_o vertical line.

q. Adjust A9R18 so that the pips coincide with the extreme left and right graticule vertical lines.

r. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the internal 160-MHz marker pip at the graticule f_o vertical line.

s. Disconnect the equipment from the setup of figure 4-20.

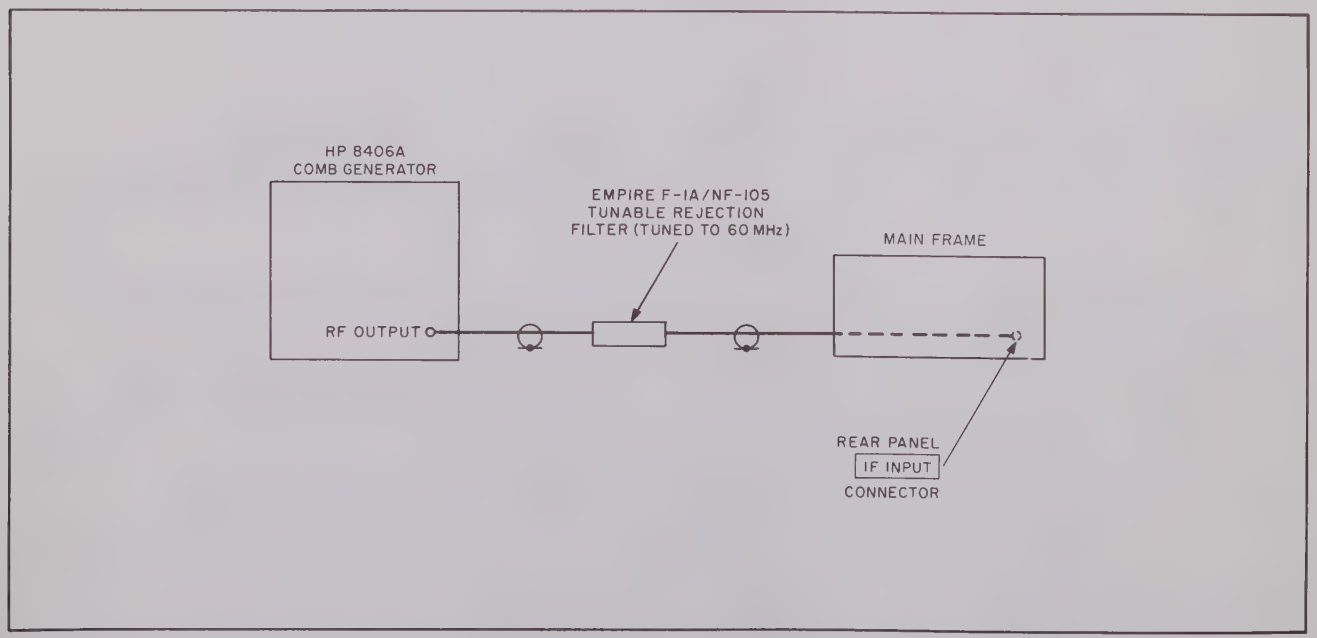


Figure 4-20. Swept Oscillator A2A7 Alignment, Equipment Setup

t. Couple an HP 608C Signal Generator, tuned to 160 MHz and adjusted for minimum output level, to the rear-panel IF INPUT connector.

u. Set the FREQ DISPERSION switch to .3 MHz/DIV and rotate the MARKER LEVEL control fully counterclockwise to OFF.

v. Increase the signal generator output level to -45 dBm and adjust the IF GAIN control to position the pip peak coincident with the LOG scale 0 DB line.

w. Tune the signal generator to 140 MHz and set its output level at -45 dBm.

x. Alternately adjust A2A7C11, A2A7T2 and A2A7R14 to minimize the pip amplitude; the pip peak should be reduced to below the LOG scale 40 DB line.

y. Set the FREQ DISPERSION switch to 10 MHz/DIV, set the signal generator for minimum output level, set the AMPLITUDE SCALE switch to LIN and rotate the IF GAIN control fully counterclockwise. Adjust the V POS screwdriver control to position the trace at the lowest graticule horizontal line.

z. Increase the signal generator output level and determine the display flatness; it should be within 2 dB.

aa. Set the FREQ DISPERSION switch to .1 MHz/DIV and rotate the BANDWIDTH VARIABLE control fully counterclockwise.

ab. Tune the signal generator to 160 MHz and adjust for minimum output level.

ac. Rotate the IF GAIN control clockwise to position the trace coincident with the LIN scale 0.2 line.

ad. Increase the signal generator output level until the signal pip peak is coincident with the LIN scale 0.4 line. Note the signal generator output level; it should be equal to or less than -110 dBm.

4-26. 60-MHz I-F AMPLIFIER A2A8. To align the 60-MHz i-f amplifier, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-21.

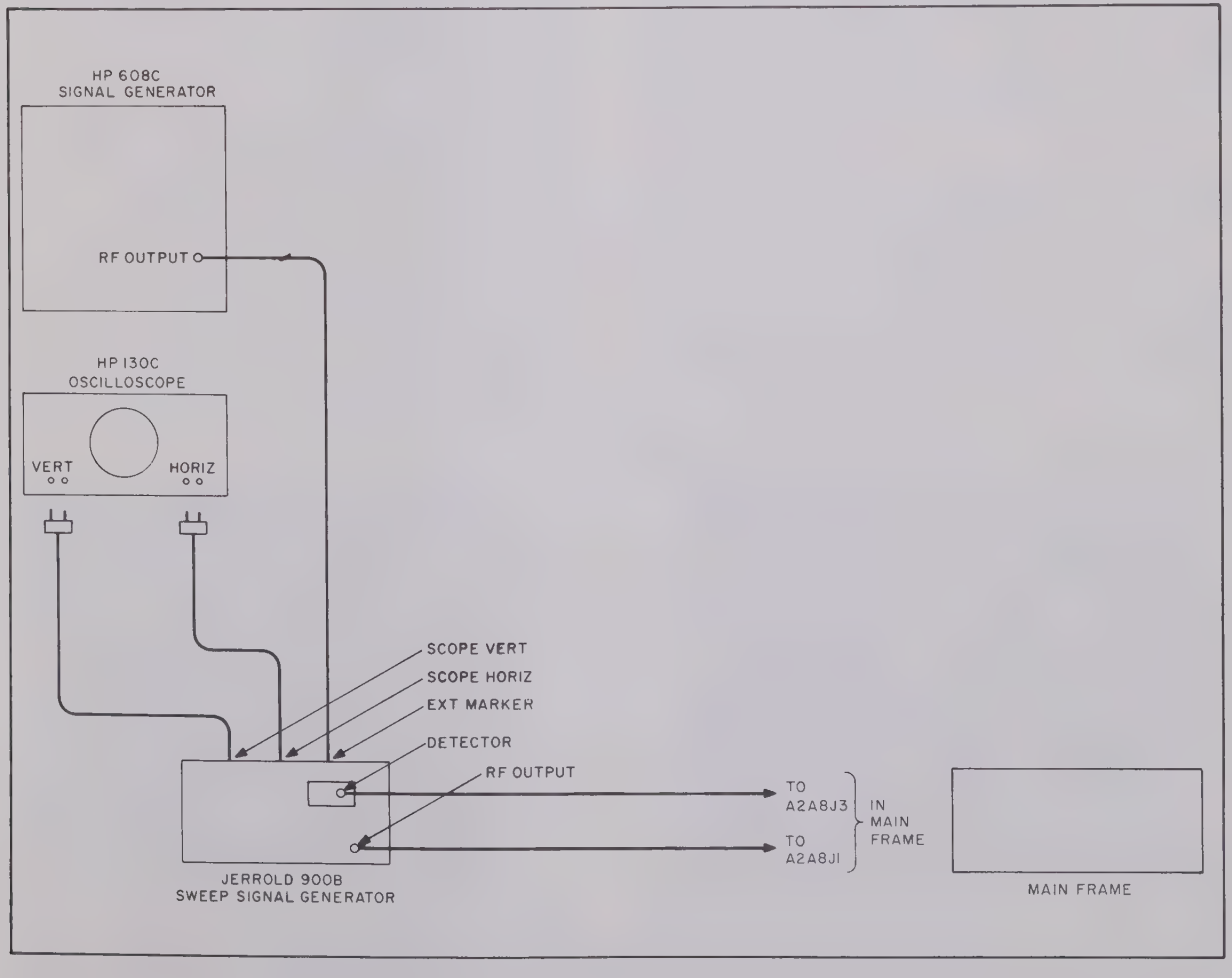


Figure 4-21. 60-MHz I-F Amplifier A2A8 Alignment, Equipment Setup

b. Tune the sweep generator to a center frequency of 60 MHz, a sweepwidth of 20 MHz and an output level of -10 dBm. Tune the signal generator for a 60-MHz marker output.

c. Adjust A2A8L4 and A2A8L1 to obtain an optimum response at 60 MHz. The frequency response should be symmetrical about 60 MHz and have a 3-dB bandwidth of between 8 and 10 MHz.

d. Disconnect A2P10 from A2A8J3 and disconnect A2W9P1 from A2A8J2. Connect A2P10 to A2A8J2.

e. Rotate the IF GAIN control fully counterclockwise.

f. Adjust A2A8L6, A2A8L8 and, if necessary, A2A8L4, to obtain an optimum response at 60 MHz. The frequency response should be symmetrical about 60 MHz and have a 3-dB bandwidth of between 3 and 5 MHz.

g. Connect A2P10 to A2A8J3 and connect A2W9P1 to A2A8J2.

4-27. 60/6.5-MHz CONVERTER A2A9. To align this converter, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Rotate the MARKER LEVEL control fully clockwise.

b. Adjust A2A9L1 until the marker pip is displayed on the screen.

c. Adjust A2A9T2 and A2A9T3 to obtain a pip display of maximum amplitude.

d. Adjust A2A9T1 for minimum pip height and then rotate tuning slug counterclockwise to obtain a pip display of maximum height.

e. Rotate the slug of A2A9L1 counterclockwise until pip disappears. Rotate the slug clockwise until the pip reappears and then rotate an additional 1/2-turn clockwise.

4-28. ALIGNMENT PROCEDURES, BACK I-F ASSEMBLY A3.

4-29. The procedures for aligning the various printed circuit boards within back i-f assembly A3 are detailed in paragraphs 4-30 through 4-34.

4-30. 6.5-MHz WIDEBAND FILTER A3A1. To align this filter, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for a minimum cw output level. Couple the signal generator to the rear-panel IF INPUT connector. Set the FREQ DISPERSION switch to 1 MHz/DIV.

b. Increase the signal generator output level to obtain a pip peak coincident with the LOG scale 10 DB line and adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the pip at the graticule f_o vertical line.

c. Set the BANDWIDTH switch to 1000 kHz and adjust A3A1C9 to obtain a pip display of maximum amplitude at the center of the screen.

d. Adjust A3A1R11 to position the pip peak coincident with the LOG scale 20 DB line.

e. Set the IF ATTENUATOR switches to 20 DB and set the AMPLITUDE SCALE switch to LIN. Readjust A3A1C9 to peak the response at the center of the screen and adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line.

f. Determine the width of the pip at the LIN scale 0.7 point; it should be between 0.9 and 1.1 divisions.

4-31. 6.5-MHz NARROWBAND FILTER A3A2. To align this filter, set the front-panel controls as listed in paragraph 4-19 and then continue as directed in the following steps.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for minimum cw output level. Couple the signal generator to the rear-panel IF INPUT connector through a Kay 30-0 Step Attenuator. Set the attenuator for 0-dB insertion.

b. Set the BANDWIDTH switch to 10 kHz and set the FREQ DISPERSION switch to 100 kHz/DIV.

c. Increase the signal generator output level to obtain a display of convenient amplitude.

d. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the pip at the graticule f_o vertical line.

e. Disconnect A3W4P1 from A3A2J2 and disconnect A3W5P2 from A3A4J1. Connect length of 50-ohm coaxial cable between A3A2J2 and A3A4J1.

f. Increase the signal generator to obtain a pip peak coincident with the LOG scale 10 DB line.

g. Adjust A3A2C3, A3A2C5, A3A2C7, A3A2C9, A3A2C11, A3A2C13, A3A2C15 and A3A2C17 to obtain a maximum pip amplitude at the graticule f_o vertical line. Retune the above capacitors several times to obtain a smooth symmetrical response about the f_o line.

h. Set the external attenuator for 40-dB insertion, set the AMPLITUDE SCALE switch to LIN and adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.

i. Determine the width of the display at the LIN scale 0.7 point; it should be between 1.5 and 2 divisions wide. The pip should also be smooth and symmetrical about the graticule f_o vertical line. Note that it may be necessary to repeat steps a through i several times until the proper response is obtained.

j. After the proper response has been obtained, connect A3W4P1 to A3A2J2 and connect A3W5P2 to A3A4J1.

4-32. 6.5-MHz VARIABLE BANDWIDTH AMPLIFIER A3A3. To align the variable bandwidth amplifier, set the front panel controls as listed in paragraph 4-19 and then continue as directed in the following steps.

a. Rotate screwdriver controls A9R6 (A 50 kHz Adj), A9R4 (A 1.5 kHz Adj), A9R10 (B 50 kHz Adj), and A9R8 (B 1.5 kHz Adj) fully clockwise.

b. Tune an HP 608C Signal Generator to 160 MHz and adjust for a cw output level of -45 dBm.

c. Set the BANDWIDTH switch to VAR and set the FREQ DISPERSION switch to 100 kHz/DIV.

d. Adjust the SIGNAL FREQ POSITION f_o COARSE and/or FINE control to position the response at the graticule f_o vertical line.

e. Bypass 6.5-MHz narrowband filter A3A2. Note various responses to the right of the main response centered on the screen.

f. Remove A3A3Y2 from its socket and note the fundamental response of the crystal at the center of the screen.

g. Rotate the BANDWIDTH VARIABLE control counterclockwise until a significant reduction of the broadband response is obtained.

h. Adjust A3A3C13 to minimize the response on the left side of the screen.

i. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L5 to minimize the fundamental response at the center of the screen (until the top of the display is flat).

j. Adjust A3A3C11 to obtain maximum rejection on the right side of the fundamental response (see figure 4-22a).

k. Rotate the BANDWIDTH VARIABLE control counterclockwise until the width of the fundamental response is two (2) divisions wide when measured 25 dB below its peak (see figure 4-22b).

l. Adjust A3A3C13 to obtain symmetry about the fundamental response (down to 25 dB below the peak).

m. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L5 to obtain a flat response (see figure 4-22a).

n. Trim A3A3C11 for maximum skirt rejection.

o. Repeat steps k and l.

p. Set the FREQ DISPERSION switch to 30 kHz/DIV and set the AMPLITUDE SCALE switch to LIN.

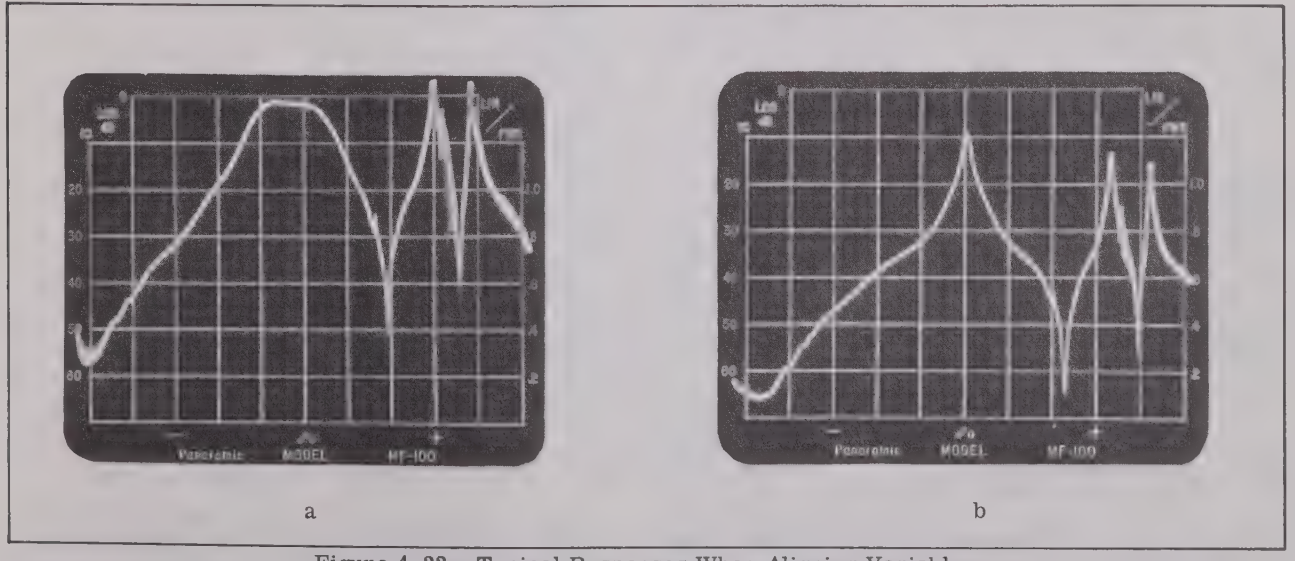
q. Adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.

r. Adjust A3A3L5 to obtain a flat response.

s. Set the BANDWIDTH switch to 30 kHz, set the FREQ DISPERSION switch to 10 kHz/DIV and adjust screwdriver control A9R6 (A 50 kHz Adj) to obtain a pip 3-dB bandwidth of 50 kHz (5 divisions).

t. Set the BANDWIDTH switch to 1 kHz, set the FREQ DISPERSION switch to 1 kHz/DIV and adjust screwdriver control A9R4 (A 1.5 kHz Adj) to obtain a pip 3-dB bandwidth of 1.5 kHz (1.5 divisions).

u. Due to interaction between controls, it may be necessary to repeat steps s and t several times until no further adjustment of either control is required to obtain the specified indications.



a b

Figure 4-22. Typical Responses When Aligning Variable Bandwidth Amplifier A3A3

v. Insert A3A3Y2 into its socket and remove A3A3Y1.

w. Set the AMPLITUDE SCALE switch to LOG repeat steps b, c and g.

x. Adjust A3A3C26 to minimize the response on the left side of the screen.

z. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L12 to minimize the fundamental response at the center of the screen (until the top of the display is flat).

aa. Adjust A3A3C27 to obtain maximum rejection on the right side of the fundamental response (see figure 4-22a).

ab. Rotate the BANDWIDTH VARIABLE control counterclockwise until the width of the fundamental response is two (2) divisions wide when measured 30 dB below its peak (see figure 4-22b).

ac. Adjust A3A3C26 to obtain symmetry about the fundamental response (down to 30 dB below the peak).

ad. Rotate the BANDWIDTH VARIABLE control fully clockwise and adjust A3A3L12 to obtain a flat response (see figure 4-22b).

ae. Trim A3A3C27 for maximum skirt rejection.

af. Repeat steps ab and ac.

ag. Set the FREQ DISPERSION switch to 30 kHz/DIV and set the AMPLITUDE SCALE switch to LIN.

ah. Adjust the signal generator output level to obtain a pip peak coincident with the LIN scale 1.0 line.

ai. Adjust A3A3L12 to obtain a flat response.

aj. Set the BANDWIDTH switch to 30 kHz, set the FREQ DISPERSION switch to 10 kHz/DIV and adjust screwdriver control A9R10 (B 50 kHz Adj) to obtain a pip 3-dB bandwidth of 50 kHz (5 divisions).

ak. Set the BANDWIDTH switch to 1 kHz, set the FREQ DISPERSION switch to 1 kHz/DIV and adjust screwdriver control A9R8 (B 1.5 kHz Adj) to obtain a pip 3-dB bandwidth of 1.5 kHz (1.5 divisions).

al. Due to interaction between controls, it may be necessary to repeat steps aj and ak several times until no further adjustment of either control is required to obtain the specified indications.

am. Replace A3A3Y1 into its socket.

an. Adjust A3A3C5 and A3A3C23 to obtain a maximum amplitude response for the main pip.

ao. Replace 6.5-MHz narrowband filter A3A2 into the signal path.

ap. Adjust A3A3C29 to obtain a flat-topped response.

aq. Set the BANDWIDTH switch to 1000 kHz, set the FREQ DISPERSION switch to 1 MHz/DIV and set the AMPLITUDE SCALE switch to LOG. Adjust the signal generator output level to obtain a pip peak coincident with the LOG scale 20 DB line.

ar. Set the BANDWIDTH switch to 100 kHz and adjust A3A3R25 so that the pip peak is coincident with the LOG scale 10 DB line.

4-33. LOG AMPLIFIER A3A4. To align the log amplifier, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for a cw output level of -45 dBm. Connect the signal generator to the rear-panel IF INPUT connector through a Kay 30-0 (432C) Step Attenuator. Set the external attenuator for 0 dB insertion.

b. Set the BANDWIDTH switch to 10 kHz, set the FREQ DISPERSION switch to 0.1 MHz/DIV and adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to position the signal at the graticule f_0 vertical line.

c. Adjust the V POS screwdriver control to position the trace baseline coincident with the lowest graticule horizontal line.

d. Set the IF ATTENUATOR switches to 40 DB and set the AMPLITUDE SCALE switch to LIN.

e. Adjust A3A4C6, A3A4C12, A3A4C16 and A3A4C26 to maximize the pip amplitude.

f. Adjust the IF GAIN control to position the pip peak coincident with the LIN scale 1.0 line.

g. Set the AMPLITUDE SCALE switch to LOG and adjust A3A4C36 and A3A4C44 for maximum pip amplitude.

h. Set the IF ATTENUATOR switches to 60 DB and adjust A3A4R44 to position the pip peak coincident with the LOG scale 60 DB line.

i. Set the IF ATTENUATOR switches to 00 DB and adjust A3A4R48 to position the pip peak coincident with the LOG scale 0 DB line.

j. Set the external attenuator for 10 dB insertion and note the position of the pip peak; it should be within ±0.2 divisions of the LOG scale 10 DB line. If it is not, continue as directed in the following additional steps.

1. Adjust the IF GAIN control to obtain a pip peak coincident with the LOG scale 10 DB line.

2. Insert 50-dB of external attenuation and adjust A3A4R44 to obtain a pip peak coincident with the LOG scale 60 DB line.

3. Remove 60-dB of external attenuation and adjust A3A4R48 to obtain a pip peak coincident with the LOG scale 0 DB line.

k. Repeat step j.

l. Insert 50-dB of external attenuation (in 10-dB increments) and, after each step, note the position of the pip peak; it should be within ±0.2 divisions of the appropriate LOG scale line.

4-34. LIN/POWER AMPLIFIER A3A5. To align the lin/power amplifier, set the front panel controls as listed in paragraph 4-19 and then continue as directed below.

a. Tune an HP 608C Signal Generator to 160 MHz and adjust for minimum output level. Couple the signal generator, through a Kay 30-0 Step Attenuator, to the rear-panel IF INPUT connector. Set the step attenuator for 0-dB insertion.

b. Increase the signal generator output level to obtain a pip peak coincident with the LOG scale 0 DB line.

c. Insert 40-dB of external attenuation and set the AMPLITUDE SCALE switch to LIN.

d. Rotate A3A5R8 fully counterclockwise and then adjust A3A5R11 so that the baseline coincides with the lowest horizontal graticule line.

e. Adjust A3A5C2 to obtain maximum pip amplitude and then adjust A3A5R8 to position the pip peak coincident with the LIN scale 1.0 line.

f. Set the AMPLITUDE SCALE switch to PWR.

g. Set A3A5R18 to mid-range and rotate A3A5R17 fully clockwise.

h. Adjust A3A5R21 so that the baseline coincides with the lowest horizontal graticule line.

i. Carefully rotate A3A5R17 counterclockwise until the baseline just starts to rise upscale.

j. Adjust A3A5R18 to position the pip peak coincident with the PWR scale 1.0 line.

k. Adjust A3A5R21 to position the baseline coincident with the lowest graticule horizontal line.

l. Insert 3-dB of external attenuation (a total of 43 dB) and note the position of the pip peak; it should be at the PWR scale 0.5 point. If the pip does not coincide with the PWR scale 0.5 point, adjust A3A5R17 to obtain this indication, remove 3-dB of external attenuation and repeat steps j, k and l.

4-35. ALIGNMENT PROCEDURES, SWEEP AND DEFLECTION CIRCUITRY.

4-36. To align the sweep and deflection circuitry, proceed as directed in the following steps.

a. Set the front panel controls as listed below.

Control	Setting
SCALE ILLUMINATION control	Fully cw
IF ATTENUATOR switches	00 DB
BRIGHTNESS control	Fully cw
FOCUS control	Mid-range
INTENSIFIER control	Fully ccw
FREQ DISPERSION switch	.3 MHz/DIV
FREQ DISPERSION VARIABLE control	CAL (fully cw)
MARKER MODULATION switch	OFF
MARKER LEVEL control	OFF (fully ccw)
BANDWIDTH switch	1 kHz
BANDWIDTH VARIABLE control	Fully cw
SWEEP switch	3 MS/DIV
SWEEP VARIABLE control	CAL (fully cw)
SWEEP/SYNC switch	LINE CAL
H POS screwdriver control	Mid-range
H SIZE screwdriver control	Fully ccw
V POS screwdriver control	Mid-range
AMPLITUDE SCALE switch	LOG
IF GAIN control	Fully ccw
MANUAL control	Any

b. Adjust the FOCUS control to obtain a sharply focused display.

c. Rotate the BRIGHTNESS control fully counterclockwise and then clockwise 90°. Adjust A9R27 until the display just vanishes. Adjust the BRIGHTNESS control to obtain a display of convenient intensity.

d. Adjust the H POS screwdriver control to center the display on the screen. Adjust the H SIZE screwdriver control to extend the sweep 1/4-division beyond the extreme lef-hand graticule vertical line. Adjust A5R80 to extend the sweep 1/4-division beyond the extreme right-hand graticule vertical line.

e. Rotate A4R30 fully clockwise.

f. Adjust A9R24 to obtain a display of two full periods.

g. Adjust the V POS screwdriver control so that the base of the displayed waveform coincides with the LOG scale 60 DB line.

h. Set the SWEEP/SYNC switch to LINE USE and adjust A4R1 so that the base of the displayed trace coincides with the LOG scale 60 DB line.

i. Set the SWEEP/SYNC switch to LINE CAL and adjust A4R30 so that the displayed waveform is five divisions high.

j. Adjust the V POS screwdriver control so that the bottom of the displayed waveform is 1/2-division below the lowest horizontal graticule line.

k. Set the SWEEP/SYNC switch to LINE USE and adjust A4R1 to position the base of the displayed trace coincident with the lowest horizontal graticule line.

l. Set the SWEEP/SYNC switch to LINE CAL; the uppermost portion of the displayed waveform should be coincident with the LOG scale 20 DB line.

m. Connect the equipment as illustrated in figure 4-23. Adjust the time mark generator for pulses every 5 milliseconds.

n. Set the SWEEP/SYNC switch to INT SYNC and rotate A5R95 fully clockwise.

o. Rotate the BANDWIDTH VARIABLE control counterclockwise until the time mark pulses are two divisions high.

p. Rotate A5R95 counterclockwise until the sweep just ceases.

q. Rotate the BANDWIDTH VARIABLE control fully clockwise, set the SWEEP switch to 1000 uS/DIV and set the time mark generator for pulses every 1 millisecond.

r. Adjust A9R24 so that the displayed pulses are separated by one division.

4-37. REMOVAL AND REPLACEMENT PROCEDURES.

4-38. CRT REMOVAL. To remove the CRT from the Main Frame, proceed as directed in the following steps.

WARNING

The normal operating voltages of the CRT are dangerous to life. Be sure to short all high-voltage points to ground before reaching into exposed areas around the CRT.

a. Remove the four screws that secure the bezel to the front panel and remove the bezel, graticule and the fitted gasket.

b. Remove the multipin socket at the base of the CRT and disconnect the anode connector.

c. Loosen the two screws on the clamp near the rear of the CRT.

d. Carefully withdraw the CRT. Install a replacement CRT, using the reverse of the sequence given above, but do not install the bezel and graticule and do not tighten the clamp screws.

Note

The gasket fits tightly around the CRT and is fully installed when the face of the gasket is flush with the front panel.

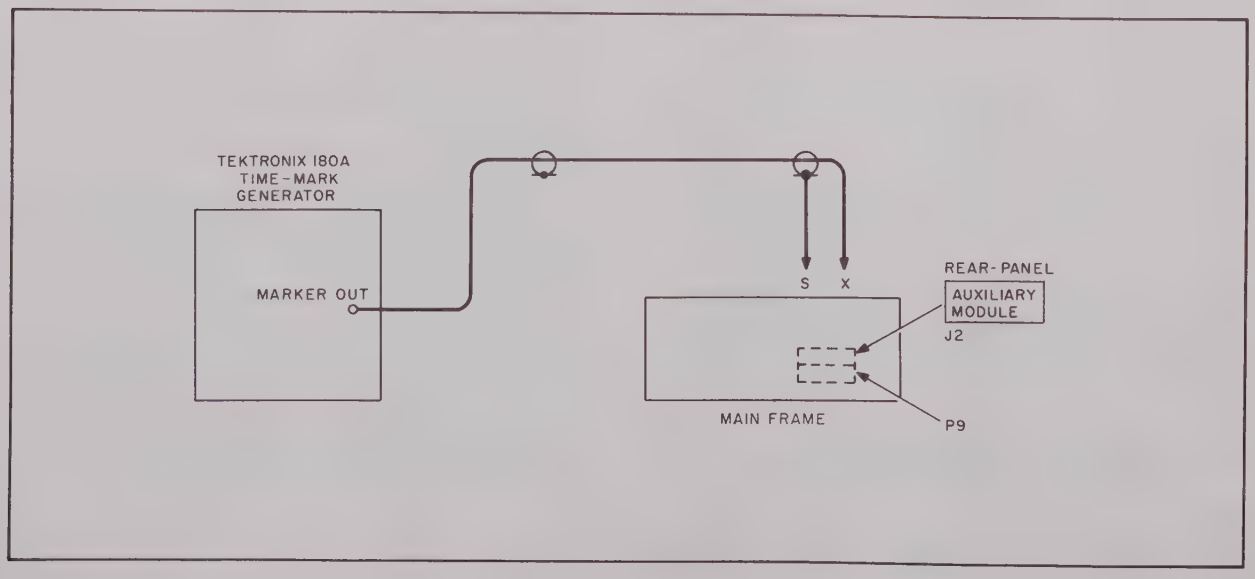


Figure 4-23. Sweep Circuitry Alignment, Equipment Setup

e. Energize the Main Frame and obtain a sharply defined trace. If the trace is tilted with respect to the horizontal, place a strip of masking tape parallel to the trace and de-energize the equipment.

f. See the warning preceding step a. Manually rotate the CRT until the masking tape is parallel to the horizontal.

g. Tighten the two clamp screws, remove the masking tape and install the graticule and bezel.

4-39. HIGH VOLTAGE POWER SUPPLY A6, REMOVAL. To remove the high-voltage power supply, proceed as directed in the following steps.

WARNING

The normal operating voltages of the CRT are dangerous to life. Be sure to short all high-voltage points to ground before reaching into exposed areas around the CRT.

a. Remove the two screws which secure the high-voltage power supply to the underside of the Main Frame.

b. Carefully grasp the side opposite the connector and, after lifting the side approximately one inch from the mounting bracket, pull the assembly from its multipin connector.

c. To gain access to the components within the assembly, remove the remaining screws and lift off the cover.

d. Before installing a replacement component, clear the area of epoxy coating. After the replacement component has been soldered in place, coat the exposed area with Polyurethane 1A27 (Humiseal Division of Columbia Technical Corp.)

4-40. I-F ATTENUATOR A1, REMOVAL. To remove the i-f attenuator assembly, proceed as follows.

a. Loosen the setscrews in each of the front panel IF ATTENUATOR knobs. Remove the knobs.

b. Disconnect the input and output cables from the assembly. It is not necessary to remove the jumper cable.

c. Remove the two screws that hold the rear plate to the frame.

d. Grasping the attenuator assembly with one hand, loosen and remove the two front panel screws (which were hidden behind the attenuator knobs) which secure the attenuator to the front panel. Carefully remove the attenuator from the Main Frame.

Note

The i-f attenuator assembly is not repairable in the field. The assembly should not be opened but should be returned to the factory for repairs.

4-41. VOLTAGE MEASUREMENTS

4-42. The voltage measurements for the active elements within the Main Frame are listed in table 4-7. Unless otherwise noted, all measurements were made with a vtvm with respect to chassis ground after the front panel controls were set per table 4-2.

TABLE 4-7. VOLTAGE MEASUREMENTS, MAIN FRAME CHASSIS

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3613	+12.5	+12.0	+12.0
Q2	2N3613	+18.0	+17.7	+12.8
Q3	2N3613	+6.9	+6.6	+0.4
Q4	2N3613	+0.2	-0.2	0
Q5	MJ2252	+100	+100	+138

TABLE 4-8. VOLTAGE MEASUREMENTS, MARKER OSCILLATOR A2A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1 [1,2]	2N3563	+0.9	0	+10.6
Q2 [1,2]	2N3563	-7.9	-7.3	-3.9
Q3 [1,3]	2N3563	-6.6	-6.0	0
Q4 [1,4]	2N3563	-7.7	-8.7	0

Notes: 1. MARKER LEVEL switch rotated clockwise from OFF position.
2. MARKER MODULATION switch set to OFF.
3. MARKER MODULATION switch set to 10 MHz.
4. MARKER MODULATION switch set to 1 MHz.

TABLE 4-9. VOLTAGE MEASUREMENTS, 160-MHz WIDEBAND AMPLIFIER A2A3

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	S24058	+2.2	+2.9	+8.6
Q2	S24058	+1.1	+1.8	+9.9
Q3	S24058	+1.1	+1.8	+10.2
Q4	S24058	+1.1	+1.8	+10.8

TABLE 4-10. VOLTAGE MEASUREMENTS, SWEPT LOCAL OSCILLATOR A2A7

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3642	-0.5	+0.5	+16.5
Q2	132-0317-001	+22.2	+21.5	+96.0
Q3	2N3563	+0.38	0	+11.2
Q4	2N3932	+4.65	+5.5	+11.8
Q5 [1]	2N3563	+0.85	0	+11.4
Q6 [1]	SE7010	+15.5	+15.5	+64.0
Q7 [1]	2N3565	-0.6	-0.03	+15.5

Notes: 1. FREQ DISPERSION switch set to .3 MHz/DIV

TABLE 4-11. VOLTAGE MEASUREMENTS, 60-MHz I-F AMPLIFIER A2A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	+5.1	+5.8	+11.6
Q2	2N3563	+5.1	+5.8	+11.6
Q3	SE5001	-1.15	-0.43	+4.0
Q4	2N3563	+5.3	+6.0	+11.7

TABLE 4-12. VOLTAGE MEASUREMENTS, 60-MHz TO 6.5-MHz CONVERTER A2A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	+4.6	+5.1	+10.2
Q2	2N3563	-6.2	-5.8	0

TABLE 4-13. VOLTAGE MEASUREMENTS, 6.5-MHz WIDEBAND FILTER A3A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3563	-5.6	-4.75	0

Note: BANDWIDTH switch set to 1000 kHz

TABLE 4-14. VOLTAGE MEASUREMENTS, 6.5-MHz NARROWBAND FILTER A3A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3694	-6.3	-5.7	0
Q2	2N3694	-6.2	-5.6	0

TABLE 4-15. VOLTAGE MEASUREMENTS, 6.5-MHz VARIABLE BANDWIDTH I-F AMPLIFIER A3A3

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3694	-0.74	-0.14	+11.0
Q2	2N3015	-0.6	0	+4.25

TABLE 4-15. VOLTAGE MEASUREMENTS, 6.5-MHz VARIABLE BANDWIDTH I-F AMPLIFIER A3A3 (Cont'd)

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q3	2N3015	-5.6	-5.0	+6.0
Q5	2N3694	-0.6	0	+5.4
Q5	2N3694	-5.8	-5.2	+5.3
Q6	2N3694	-0.6	0	+4.5
Q7	2N3694	-0.6	0	+11.5
Q8	2N3642	-1.2	-0.6	+11.4

TABLE 4-16. VOLTAGE MEASUREMENTS, LOG AMPLIFIER A3A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	SE3002	-7.3	-6.6	0
Q2	2N3646	-7.2	-6.6	0
Q3	2N3646	-7.2	-6.6	0
Q4	2N3694	-1.4	-0.84	+10.5
Q5	2N3646	-7.3	-6.7	0
Q6	2N3646	-7.5	-6.8	0
Q7	2N3646	-7.5	-7.0	0
Q8	2N3568	-0.5	+0.025	+11.9
Q9	2N3638	-11.3	-0.49	+0.18

TABLE 4-17. VOLTAGE MEASUREMENTS, LIN/POWER AMPLIFIER A3A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3641	-7.4	-6.9	+11.5
Q2	2N3568	-0.53	0	+11.6
Q3	2N3638	0	-0.53	-11.5
Q4	2N3638	+0.7	-0.06	-11.5
Q5	U148	+4.6 (S)	+9.6 (G)	-0.05 (D)
Q6	2N3568	-0.6	-0.05	+11.8
Q7	2N3638	0	-0.6	-11.5

TABLE 4-18. VOLTAGE MEASUREMENTS, DEFLECTION AMPLIFIERS A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3694	-0.55	0	+9.5
Q2	2N3694	-0.55	0	+8.8
Q3	2N3638	+9.5	+8.8	+0.126
Q4	2N3694	-0.57	0	+9.3
Q5	2N3694	-0.57	0	+8.8
Q6	2N3638	+9.5	+8.8	-0.075
Q7	2N3641	-5.1	-4.35	-4.4
Q8	2N3440	-0.3	+0.126	+126
Q9	2N3440	-4.0	-0.85	+200
Q10	2N3641	-7.0	-6.5	-2.75
Q11	2N3440	+0.58	+1.1	+150
Q12	2N3440	+0.075	+0.58	+200

TABLE 4-19. VOLTAGE MEASUREMENTS, SAWTOOTH/INTENSIFIER A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q2	2N3694	-0.6	0	+11.6
Q3	2N3641	-0.55	0	+6.7
Q4	2N3646	+3.0	+3.6	+3.2
Q5	2N3646	+3.0	+2.85	+10.6
Q6	2N3638	+10.6	+10.0	+4.9
Q7	2N3641	+4.35	+4.9	+11.6
Q8	2N3440	+5.4	+5.9	+235
Q9	2N3440	+235	+235	+297
Q10	2N3646	+5.8	+6.4	+11.7
Q11	2N3646	+5.9	+6.5	+6.4
Q12	2N3646	+6.0	+2.2	+11.0
Q13	2N3638	+5.9	+5.3	0
Q14	2N3638	+11.5	+11.6	-11.4

TABLE 4-19. VOLTAGE MEASUREMENTS, SAWTOOTH/INTENSIFIER A5 (Cont'd)

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q15	2N1480	-4.0	-11.4	+10.8
Q16	2N2945	+10.9	+10.5	+0.84
Q17	2N3638	-4.0	-4.6	-11.8
Q18	2N3641	-4.6	-4.0	0
Q19	2N3646	0	+0.76	+0.08
Q19[1]	2N3646	0	+0.74	+0.28
Q20	2N3646	0	-0.81	+11.5
Q20[1]	2N3646	0	-0.78	+11.6
Q21	2N3646	0	+0.74	+0.13
Q21[1]	2N3646	0	+0.82	+0.1
Q22	2N3646	0	+0.74	+0.06
Q22[1]	2N3646	0	-0.62	+8.8
Q23	2N3646	0	-0.72	+8.6
Q23[1]	2N3646	0	+0.72	+0.19
Q24	2N3646	0	+0.6	+0.77
Q25	2N3646	0	+0.68	+0.76
Q26	2N3646	0	+0.75	+0.1
Q27	2N3646	0	+0.73	+0.16
Q27[1]	2N3646	0	+0.72	+0.19
Q28	2N3646	0	+0.7	+0.14
Q28[1]	2N3646	0	+0.72	+0.14
Q29	2N3646	-0.8	+0.2	+12.0
Q30	2N5306	-0.26	-0.8	-12.0
Q31	2N3646	+0.69	+0.21	+9.3
Q32	2N3646	+0.69	+1.4	+0.78
Q33	2N3646	0	-0.98	+7.4
Q34	2N5306	-1.1	0	+12.0
Q35	2N5306	-1.1	0	+6.0
Q36	2N3646	+0.69	-0.2	+9.9

TABLE 4-19. VOLTAGE MEASUREMENTS, SAWTOOTH/INTENSIFIER A5 (Cont'd)

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q37	2N3646	+0.7	+1.4	+0.78
Q38	2N3646	0	-1.28	+8.2
Q39	2N3646	0	+0.56	+0.98
Q40	2N3638	+11.8	+11.6	+0.56

Notes: 1. FREQ DISPERSION switch set to 0, BANDWIDTH switch set to 1000 kHz, SWEEP switch set to 1000 uS/DIV, SWEEP/SYNC switch set to INT (red) and IF GAIN control adjusted to trigger the sweep at two divisions of noise.

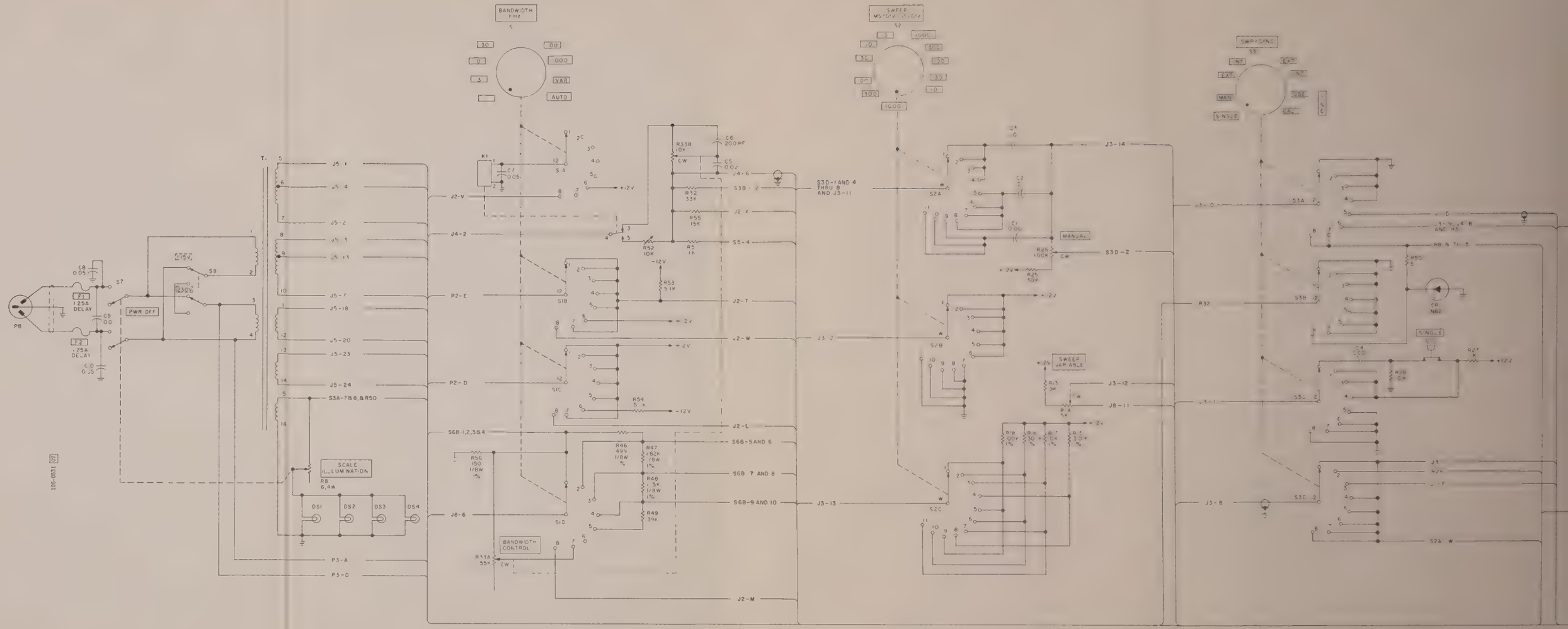
TABLE 4-20. VOLTAGE MEASUREMENTS, POWER SUPPLY CONTROL A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3440	+100	+101	+124
Q2	2N3440	+101	+101	+102
Q3	2N3440	+75	+76	+100
Q4	2N3440	+75	+76	+102
Q5	2N3638	+16	+16	+12
Q6	2N3694	+5.0	+5.6	+16
Q7	2N3694	+5.0	+5.7	+12.2
Q8	2N3638	+4.5	+3.9	+0.41
Q9	2N3694	-6.7	-6.1	+3.9
Q10	2N3694	-6.7	-6.0	+0.41

TABLE 4-21. VOLTAGE MEASUREMENTS, AUXILIARY CONTROL A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3641	-3.0	-2.5	+7.7
Q2	2N3563	-8.5	-8.0	-3.2
Q3	2N3638	+10.4	+9.8	+3.0
Q4	2N3638	+9.8	+9.2	0
Q5	2N3641	-3.0	-2.5	+9.2
Q6	2N3641	-3.0	-2.5	+9.2
Q7	2N3638	+9.8	+9.2	0
Q8	2N3638	+10.4	+9.8	+3.0
Q9	2N3563	-8.5	-8.0	-3.2
Q10	2N3641	-3.0	-2.5	+7.7

SECTION V
SCHEMATIC DIAGRAMS


BANDWIDTH KHZ
SWEEP
SWP/SYNC
PWR OFF
SCALE ILLUMINATION
BANDWIDTH CONTROL
MANUAL
SWEEP VARIABLE
SINGLE
S3D-1 AND 4 THRU 8 AND J3-11
J3-14
J3-12
J8-11
J3-13
J2-V
J4-2
P2-E
P2-D
J8-6
P3-A
P3-D
J2-M
J2-L
J2-W
J2-T
S5-4
S3B-2
S3A-7 & 8, & R50
S6B-1,2,3 & 4
S6B-5 AND 6
S6B 7 AND 8
S6B-9 AND 10
J5-24
J5-23
J5-20
J5-18
J5-7
J5-2
J5-4
J5-1
DS1
DS2
DS3
DS4
S1A
S1B
S1C
S1D
S2A
S2B
S2C
S3A
S3B
S3C
S3D
S2A W
R32
R8 & T1-5
R27
R28
R50
R33B
R32
R55
R52
R53
R54
R56
R46
R47
R48
R49
R33A
R26
R25
R18
R27
R28
C6
C5
C7
C8
C9
C10
C1
C2
C4
C3
C4
C5
C6
C7
C8
C9
C10
P8
F1
F2
1.25A DELAY
115V
230V
S7
S9
K1
T1
106-0531 07

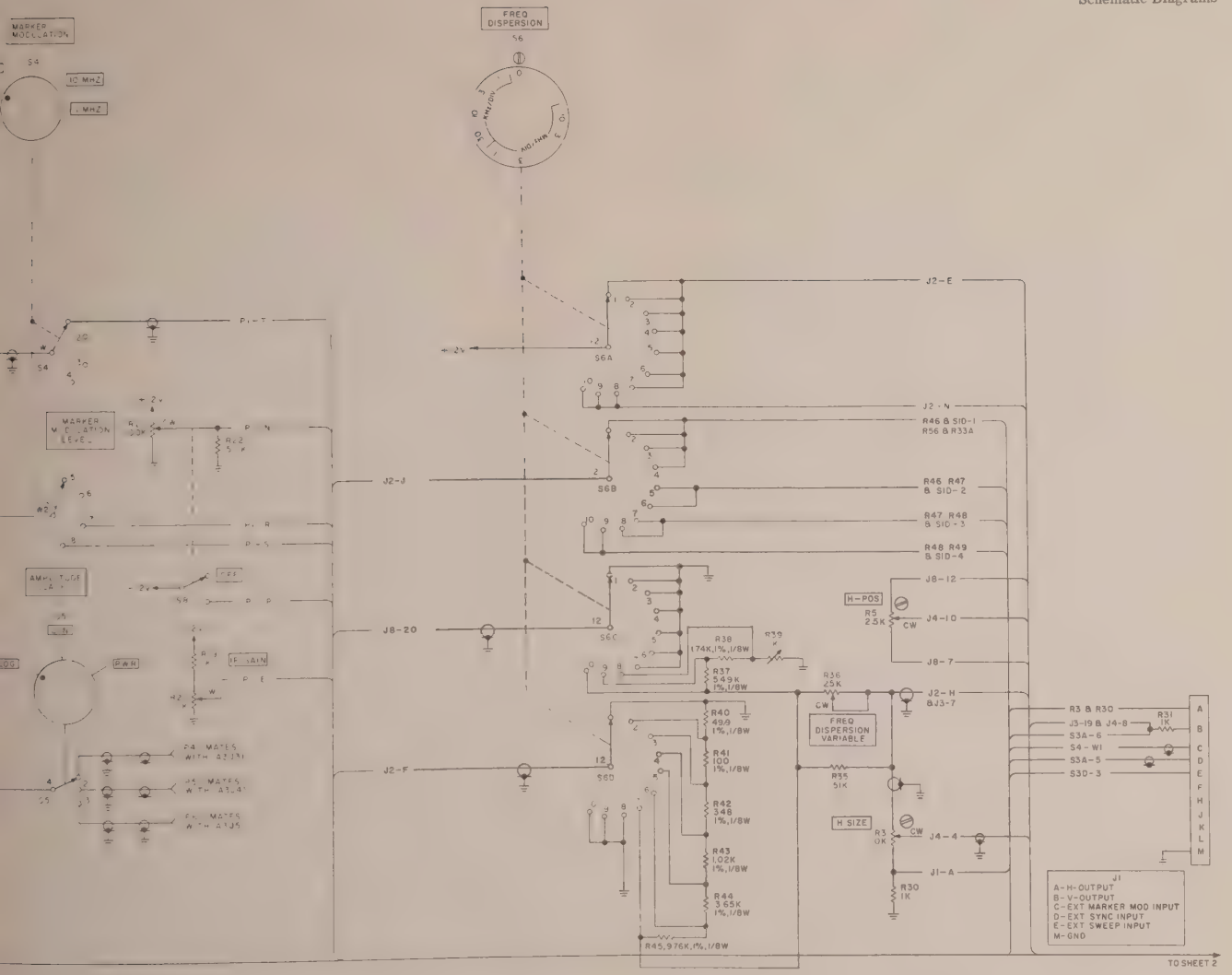


Figure 5-1. Model MF-100 Main Frame, Interconnecting Cabling Diagram (Sheet 1 of 2)

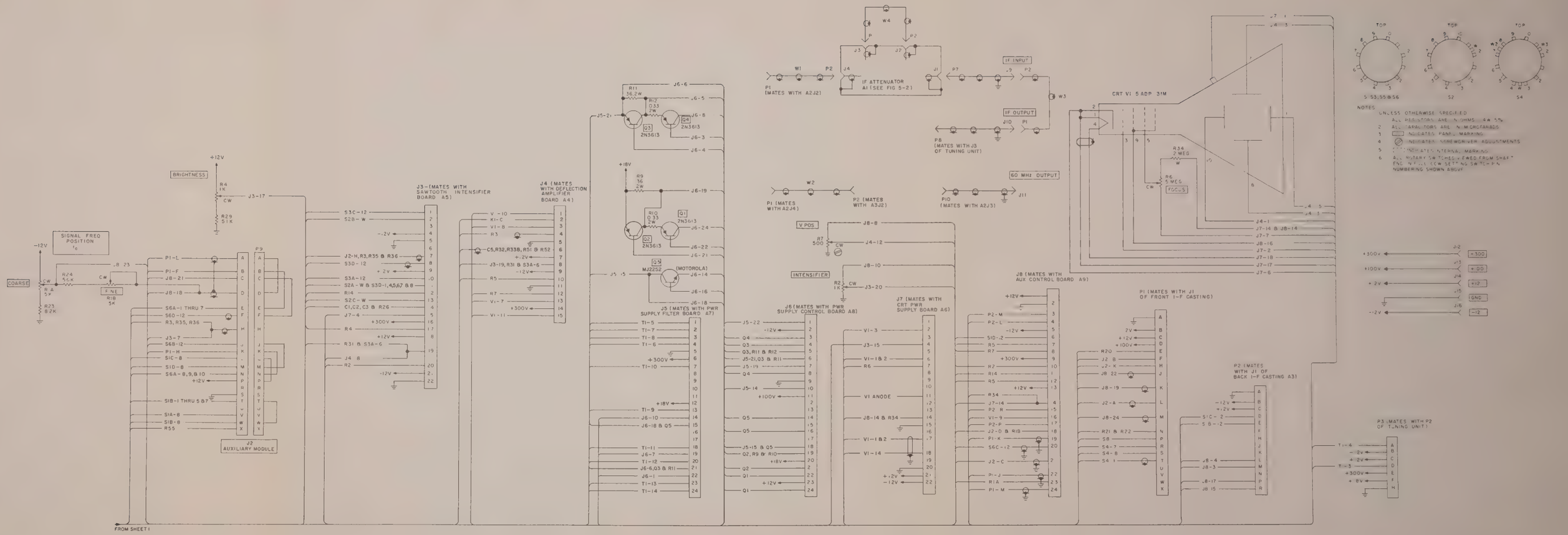
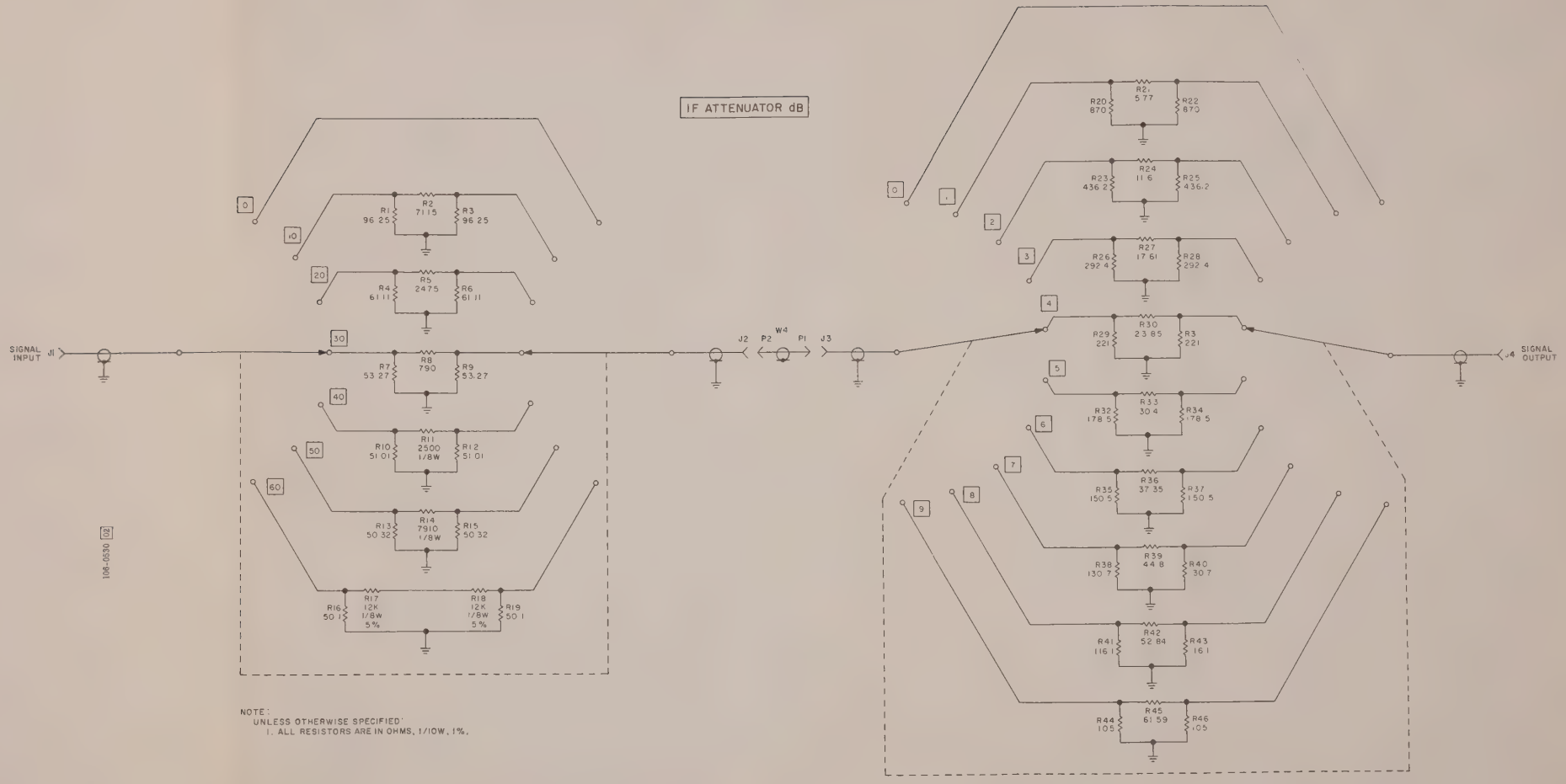


Figure 5-1. Model MF-100 Main Frame, Interconnecting Cabling Diagram (Sheet 2 of 2)



NOTE:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS, 1/10W, 1%.

Figure 5-2. I-f Attenuator A1, Schematic Diagram

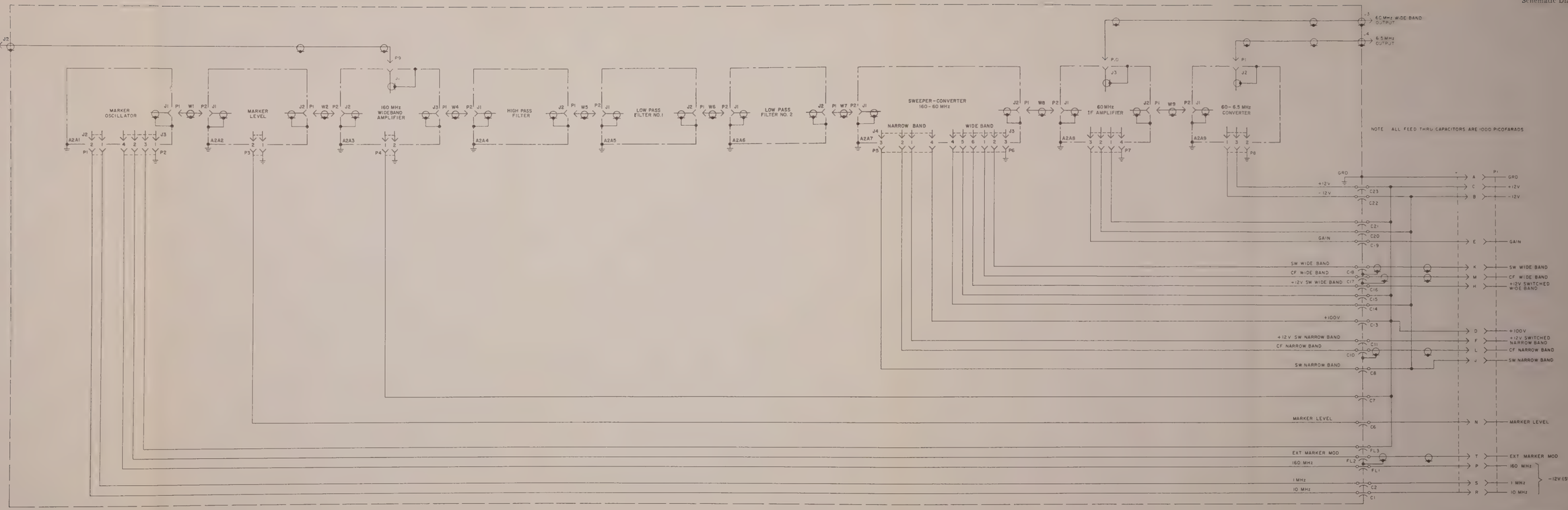
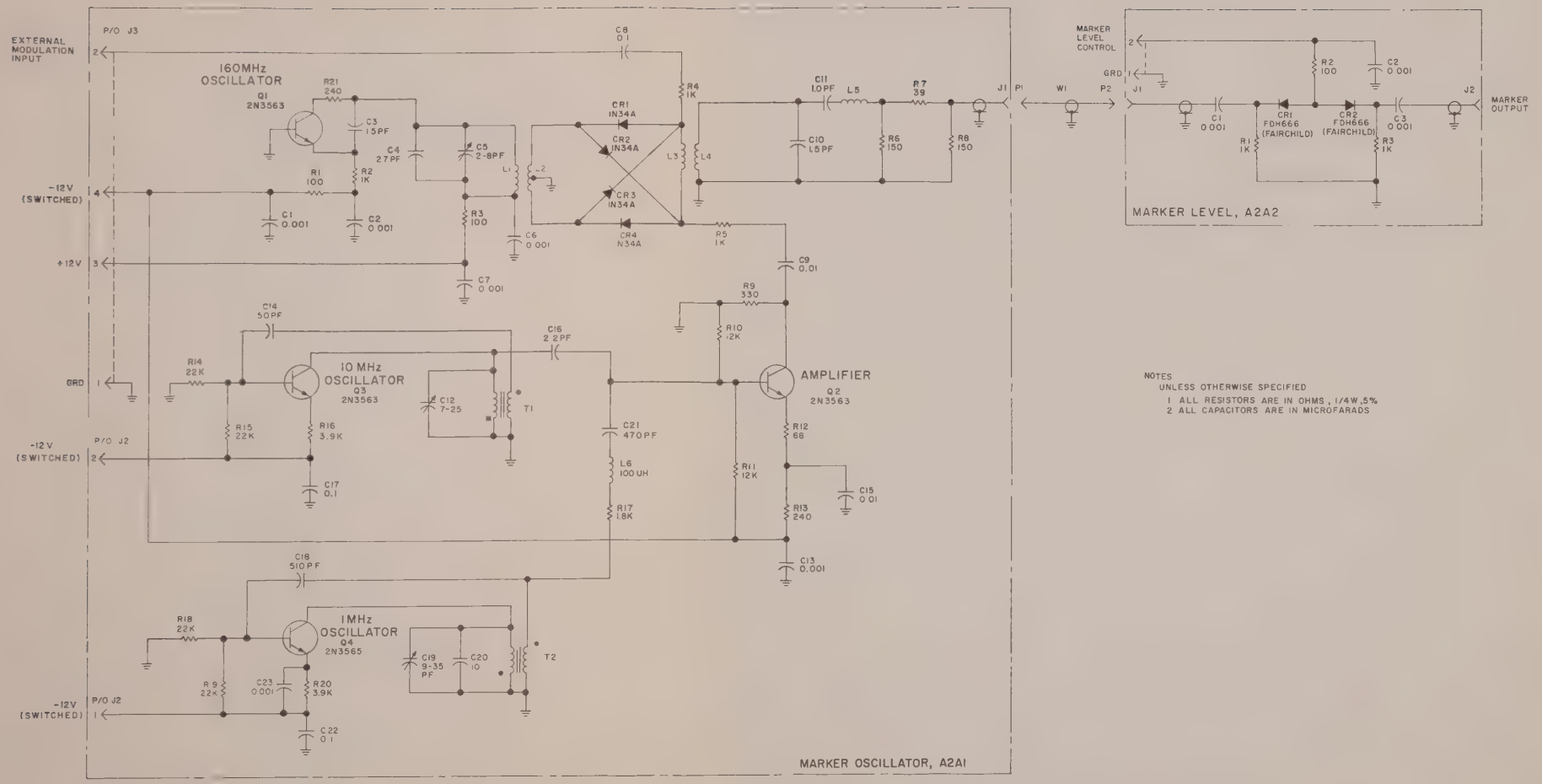


Figure 5-3. Front I-f Assembly A2, Interassembly Cabling Diagram

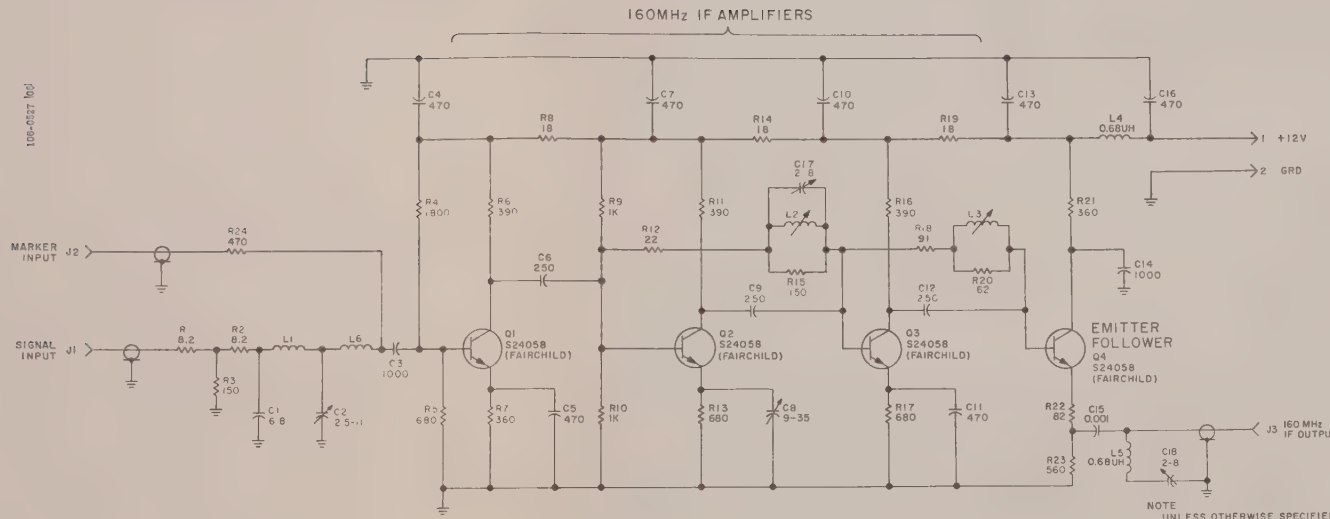
106-0058 [D]



NOTES
UNLESS OTHERWISE SPECIFIED
1 ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2 ALL CAPACITORS ARE IN MICROFARADS

Figure 5-4. Marker Oscillator A2A1 and Marker Leveler A2A2, Schematic Diagram

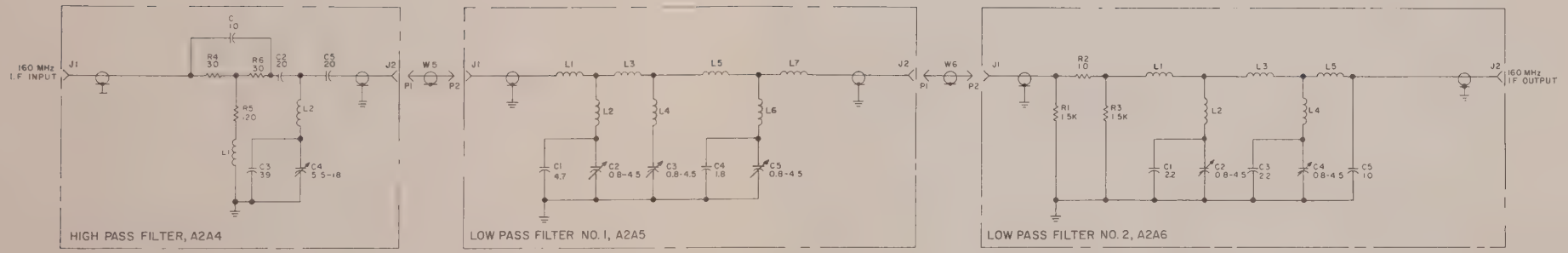
DATE	CHK	ISSUE	PCN NO.	CHANGE	DATE	CHK	ISSUE	PCN NO.	CHANGE	DATE	CHK
		03	5468	CHANGED PER PCN	4/4/68		00	4985	RELEASED PER PCN	[illegible]	[illegible]
		04	5649	changed per PCN	10/4/67		01	[illegible]	changed per PCN	[illegible]	[illegible]
		05	5778	CHANGED PER PCN 5778	12/13/68		02	5939	changed per PCN	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible] PER PCN 5913	[illegible]		[illegible]				



NOTE
UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%.
2. ALL CAPACITORS ARE IN PICOFARADS.
3. ALL INDUCTORS ARE IN MICROHENRIES.

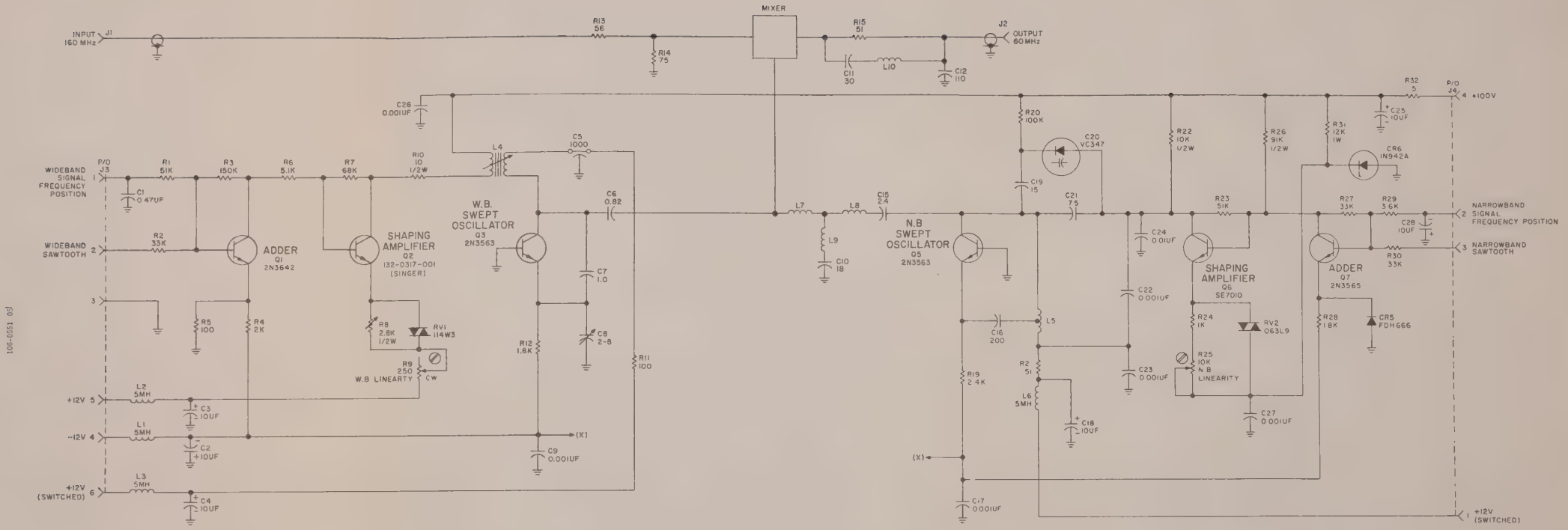
Figure 5-5. 160-MHz Wideband Amplifier A2A3, Schematic Diagram

DATE	CHK	ISSUE	PCN NO.	CHANGE	DATE	CHK	ISSUE	PCN NO.	CHANGE	DATE	CHK
							00	4985	RELEASED PER PCN	8/22/63	[illegible]
							01	5694	Changed Per PCN	12/8/68	[illegible]
							02	5510	CHANGED PER PCN 1910	[illegible]	[illegible]



NOTES
UNLESS OTHERWISE SPECIFIED,
1 ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2 ALL CAPACITORS ARE IN PICOFARADS

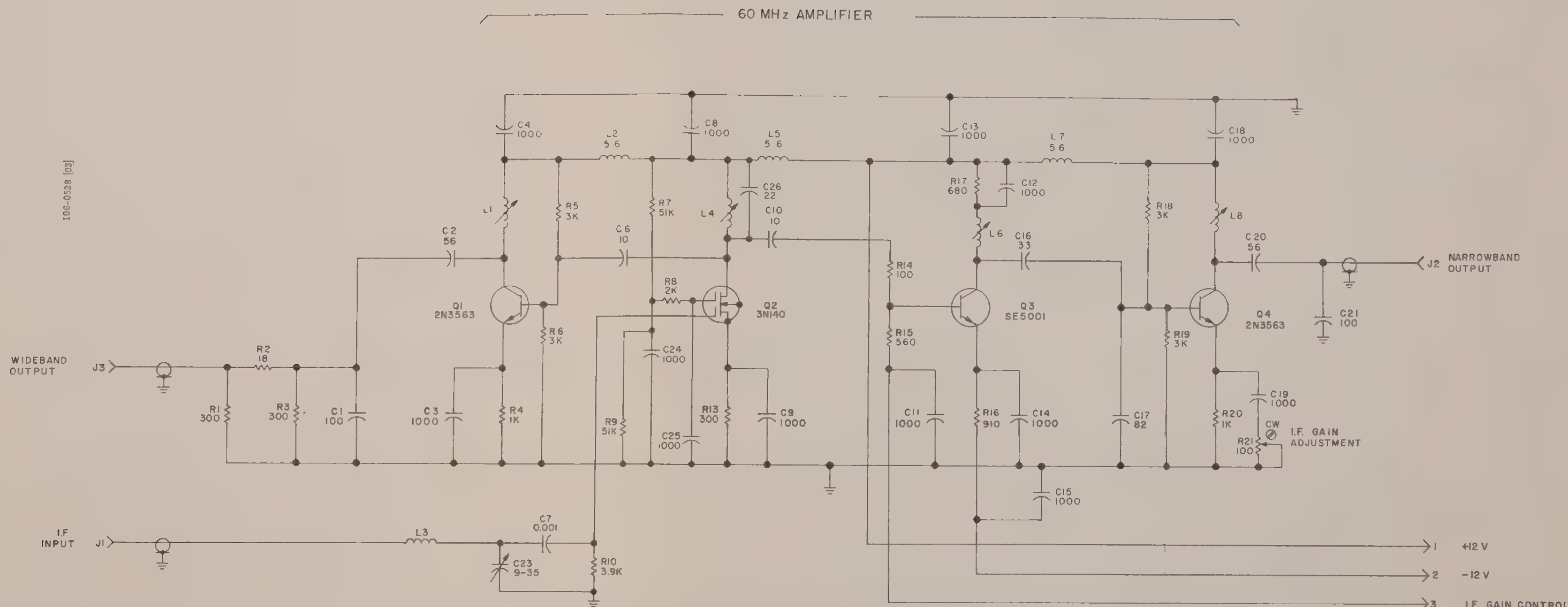
Figure 5-6. Highpass Filter A2A4 and Lowpass Filters A2A5 and A2A6, Schematic Diagram



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN PICOFARADS

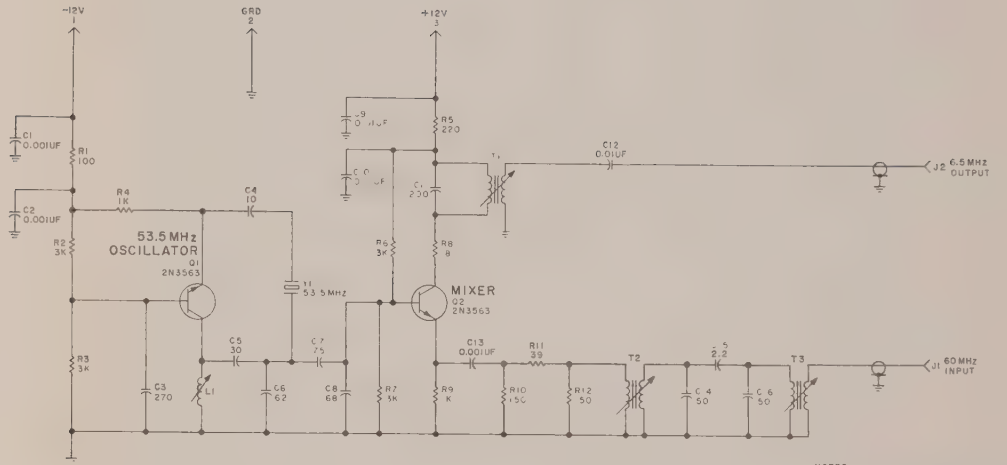
Figure 5-7. Swept Local Oscillator A2A7, Schematic Diagram

DATE	CHK	ISSUE	PCN NO.	CHANGE	DATE	CHK	ISSUE	PCN NO.	CHANGE	DATE	CHK
5/ [illegible]	[illegible]	03	[illegible]410	CHANGED PER F N 5910			00	H985	Released Per Pcn	[illegible]	[illegible]
							01	[illegible]	Changed Per Pcn	[illegible]	[illegible]
							02	5[illegible]4	Changed Per Pcn	[illegible]	[illegible]



NOTES:
UNLESS OTHERWISE SPECIFIED
1 ALL RESISTORS ARE IN OHMS, 1/4 W, 5%.
2 ALL CAPACITORS ARE IN PICOFARADS
3.ALL INDUCTORS ARE IN MICROHENRIES.

Figure 5-8. 60-MHz I-f Amplifier A2A8, Schematic Diagram



106-0059 [01]

NOTES
UNLESS OTHERWISE SPECIFIED
1 ALL RESISTORS ARE IN OHMS, 1/4W, 5%.
2 ALL CAPACITORS ARE IN PICOFARADS

Figure 5-9. 60/6.5-MHz Converter A2A9, Schematic Diagram

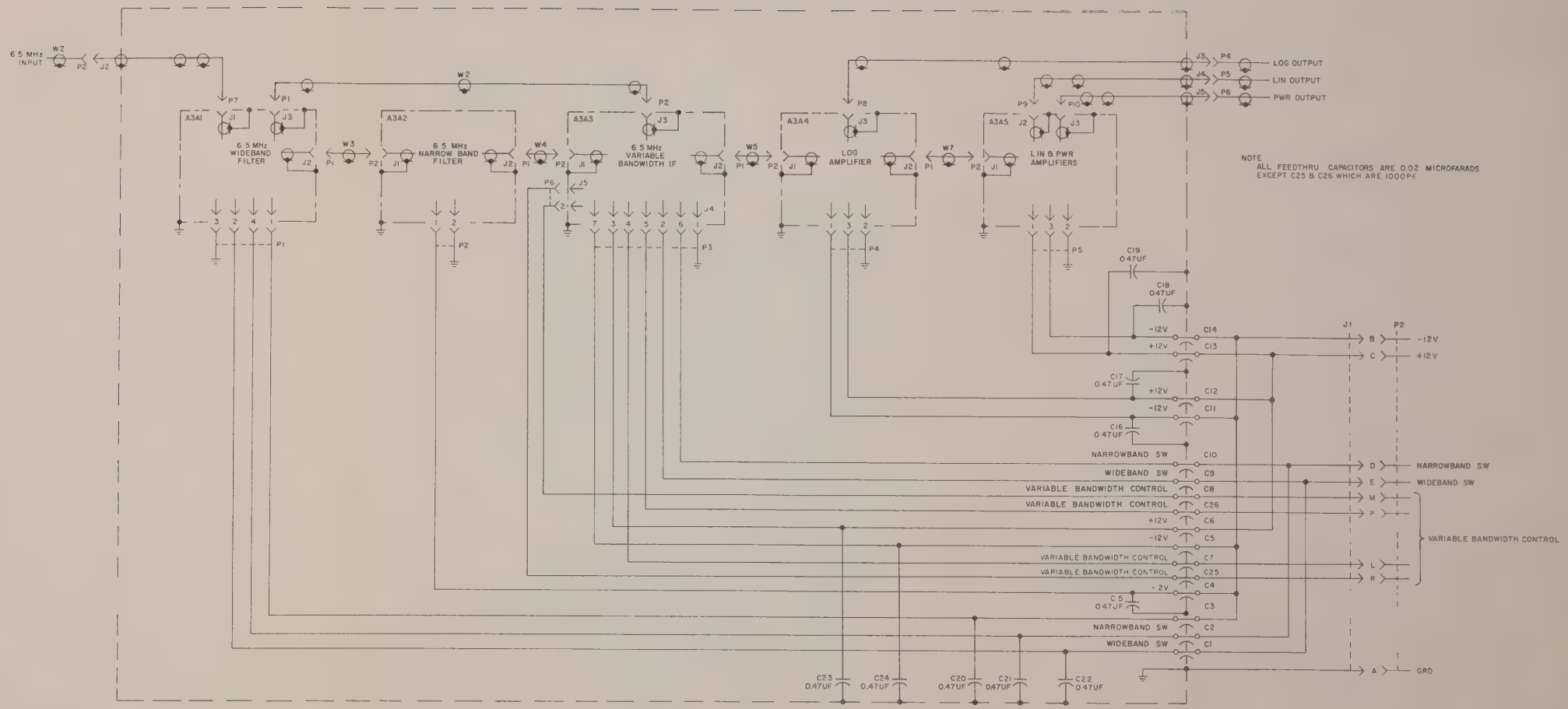


Figure 5-10. Back I-f Assembly A3, Interconnecting Cabling Diagram

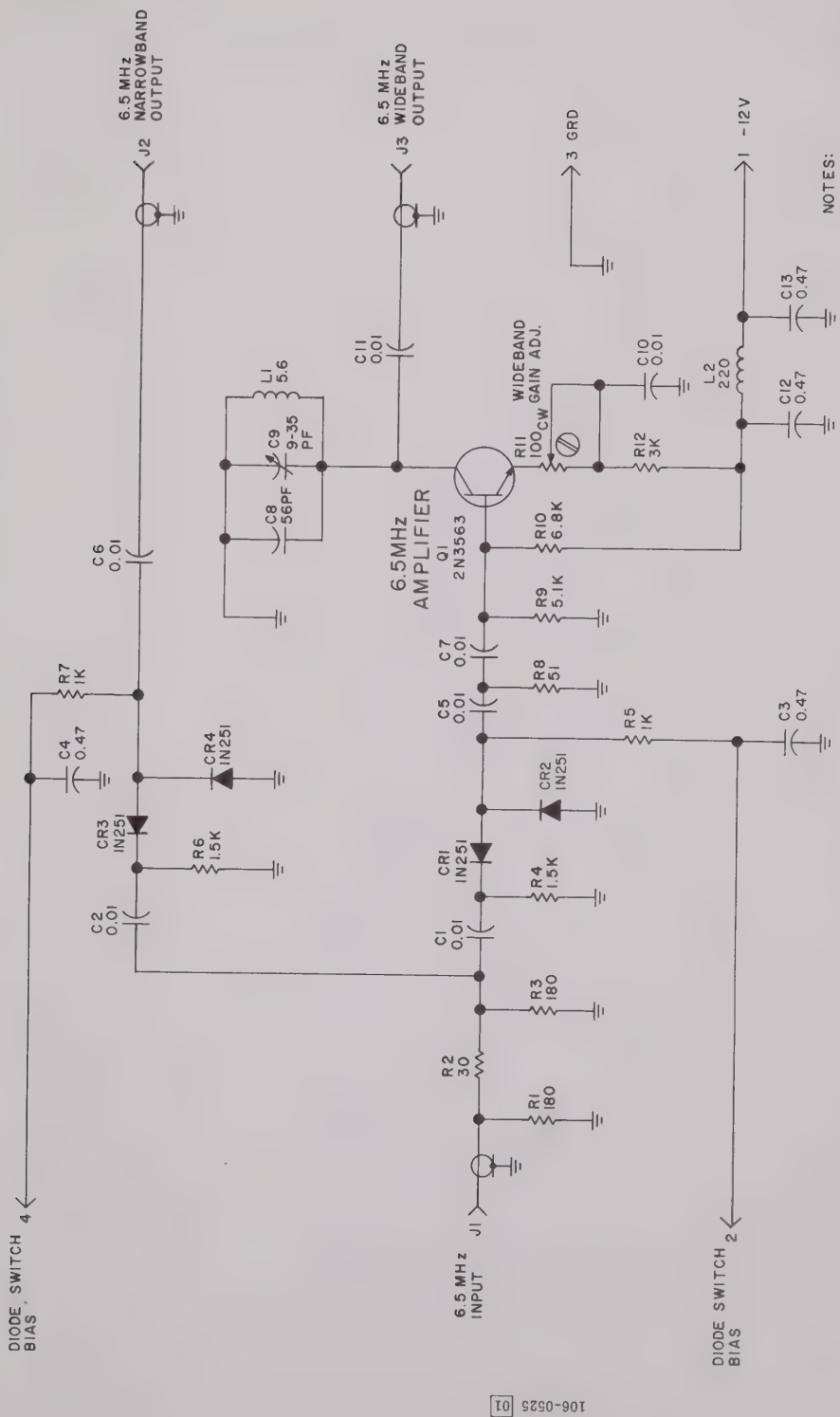


Figure 5-11. 6.5-MHz Wideband Filter A3A1, Schematic Diagram

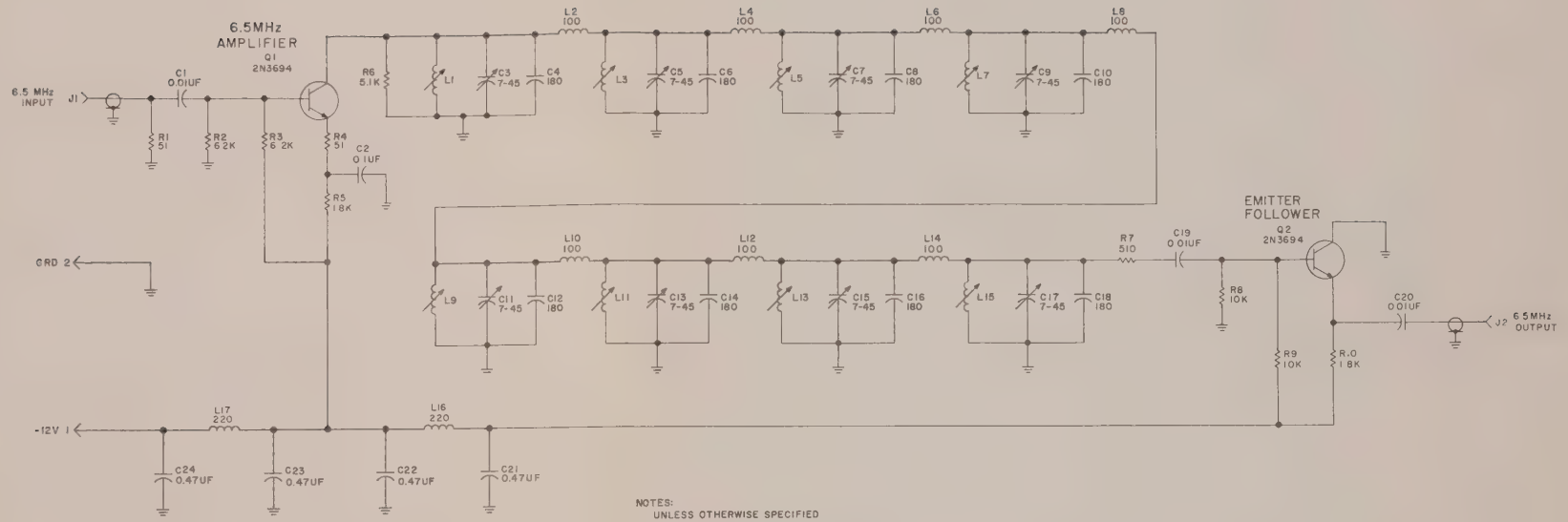


Figure 5-12. 6.5-MHz Narrowband Filter A3A2, Schematic Diagram

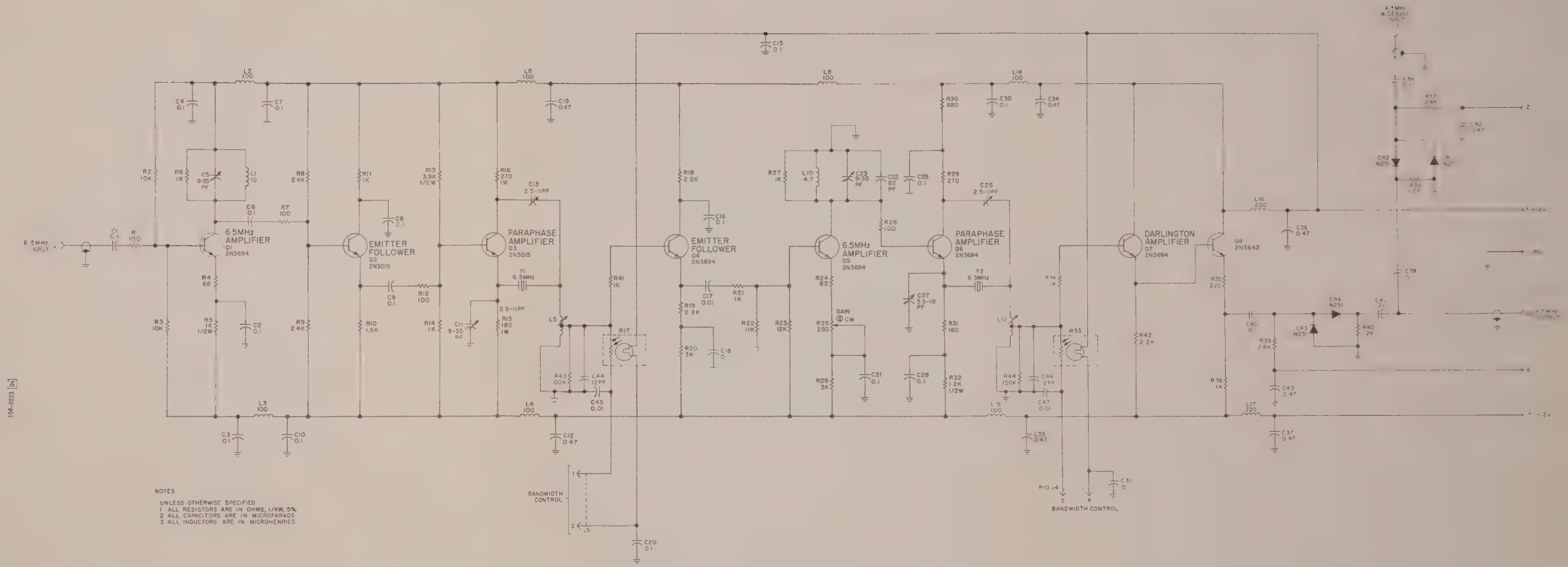


Figure 5-13. 6.5-MHz Variable Bandwidth Amplifier A3A3, Schematic Diagram

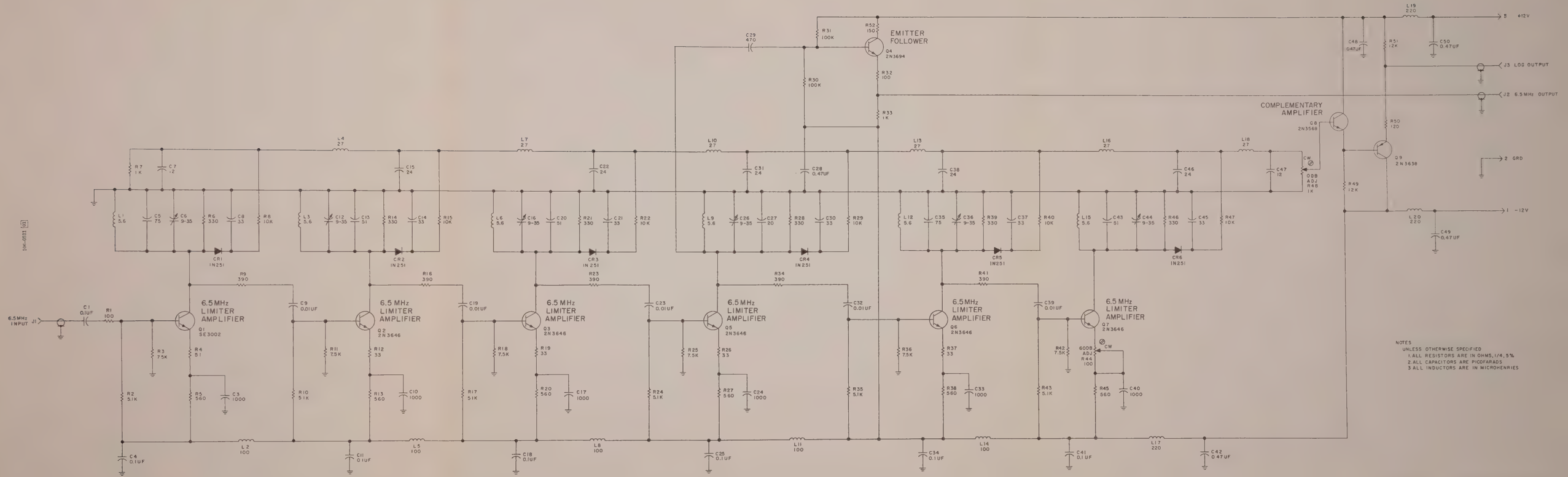


Figure 5-14. Log Amplifier A3A4, Schematic Diagram

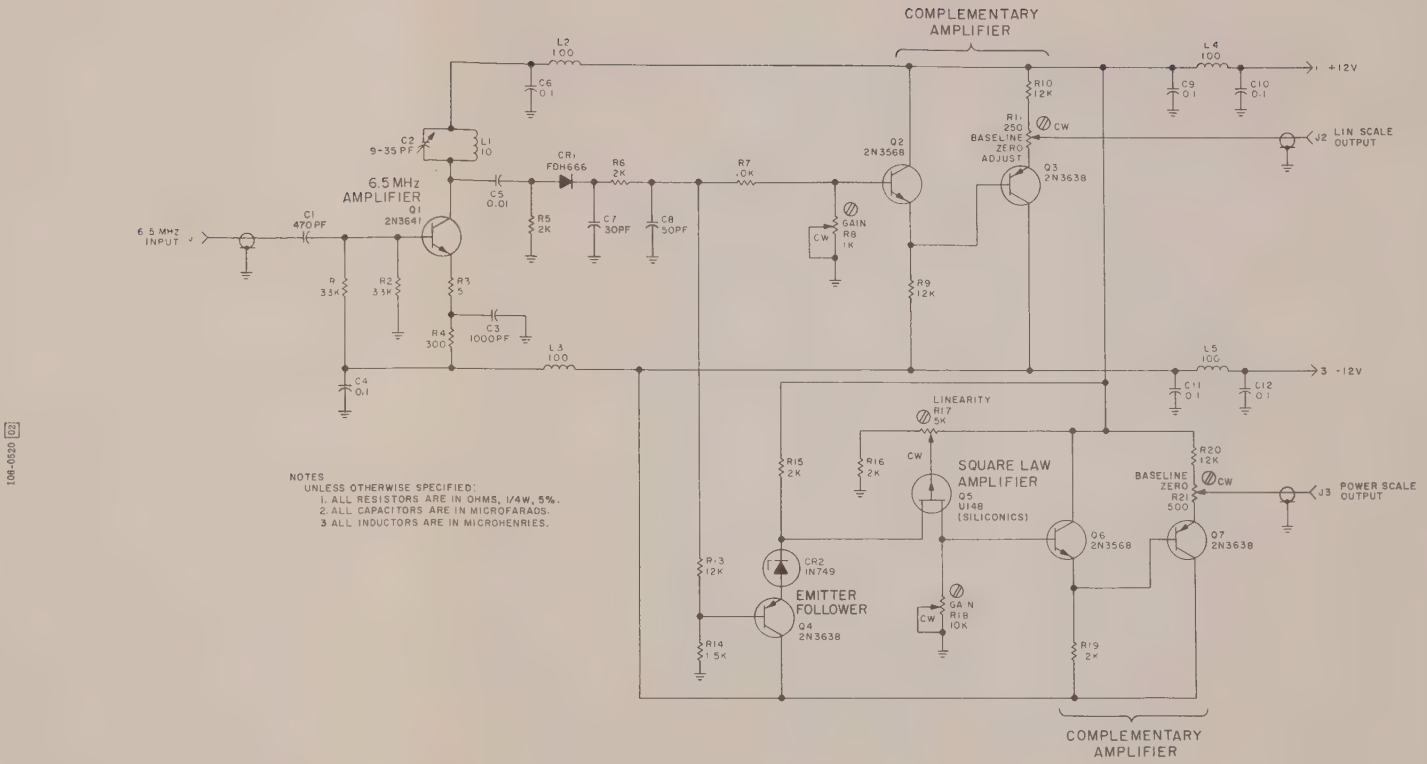


Figure 5-15. Lin/Power Amplifier A3A5, Schematic Diagram

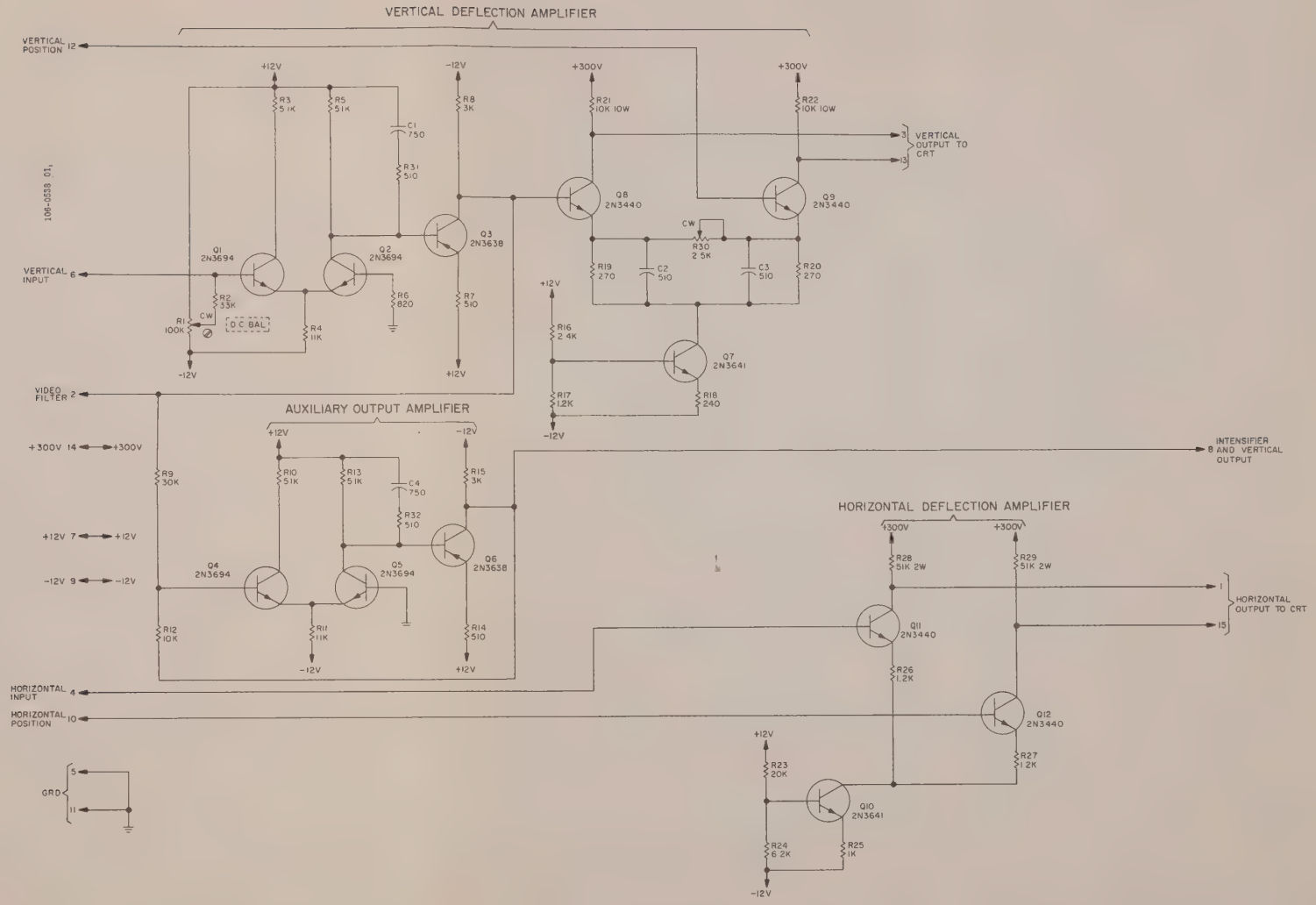


Figure 5-16. Deflection Amplifier A4, Schematic Diagram

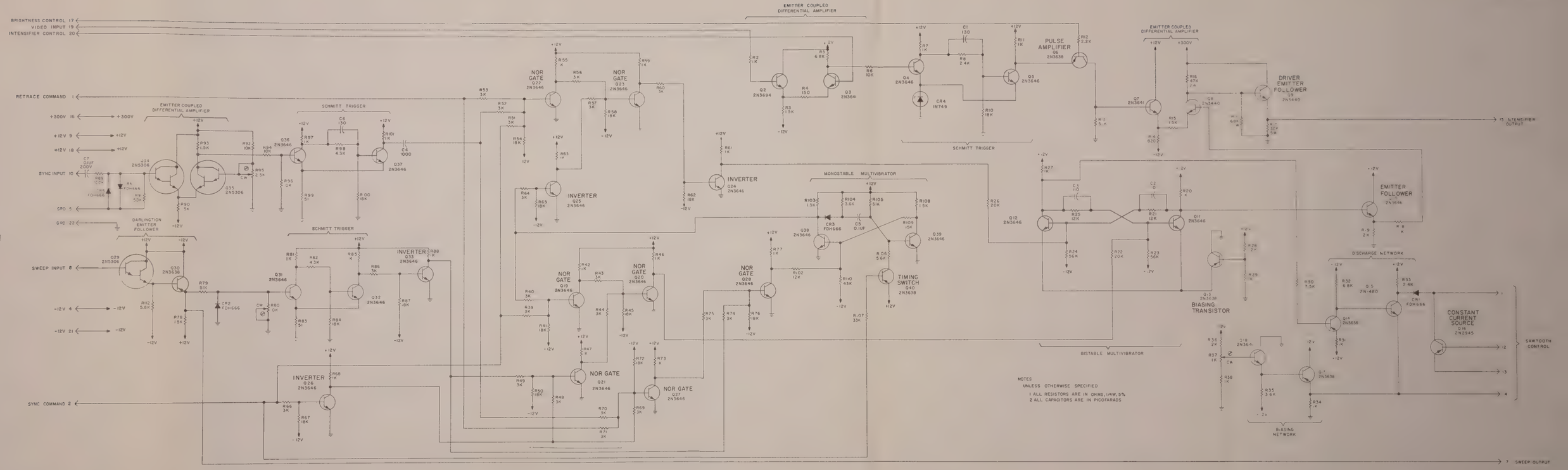


Figure 5-17. Sawtooth Intensifier A5, Schematic Diagram

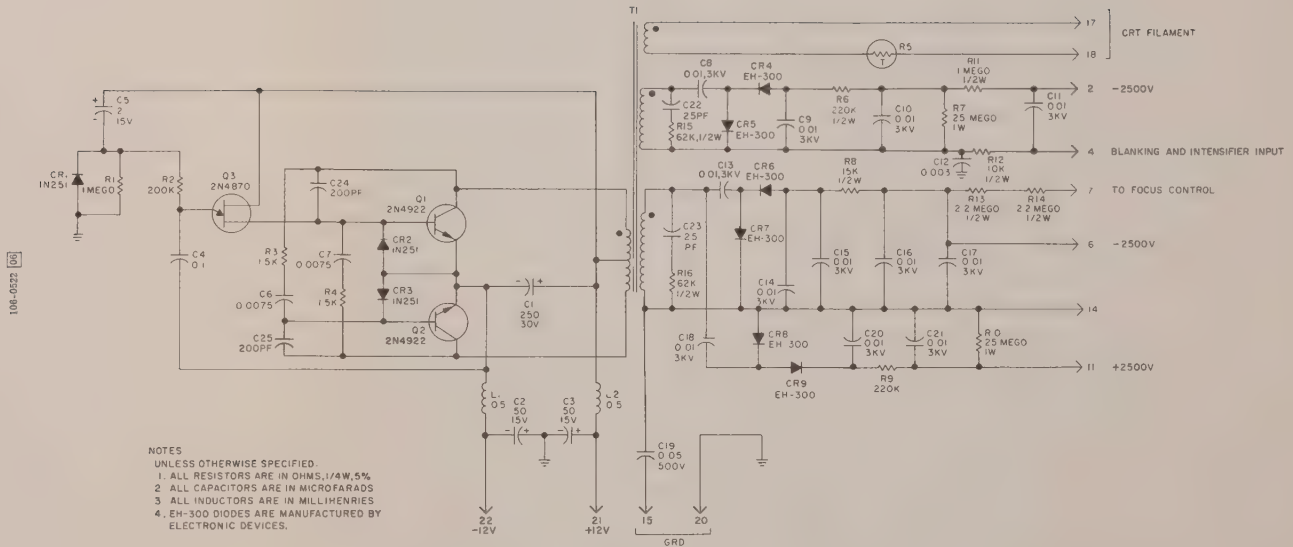
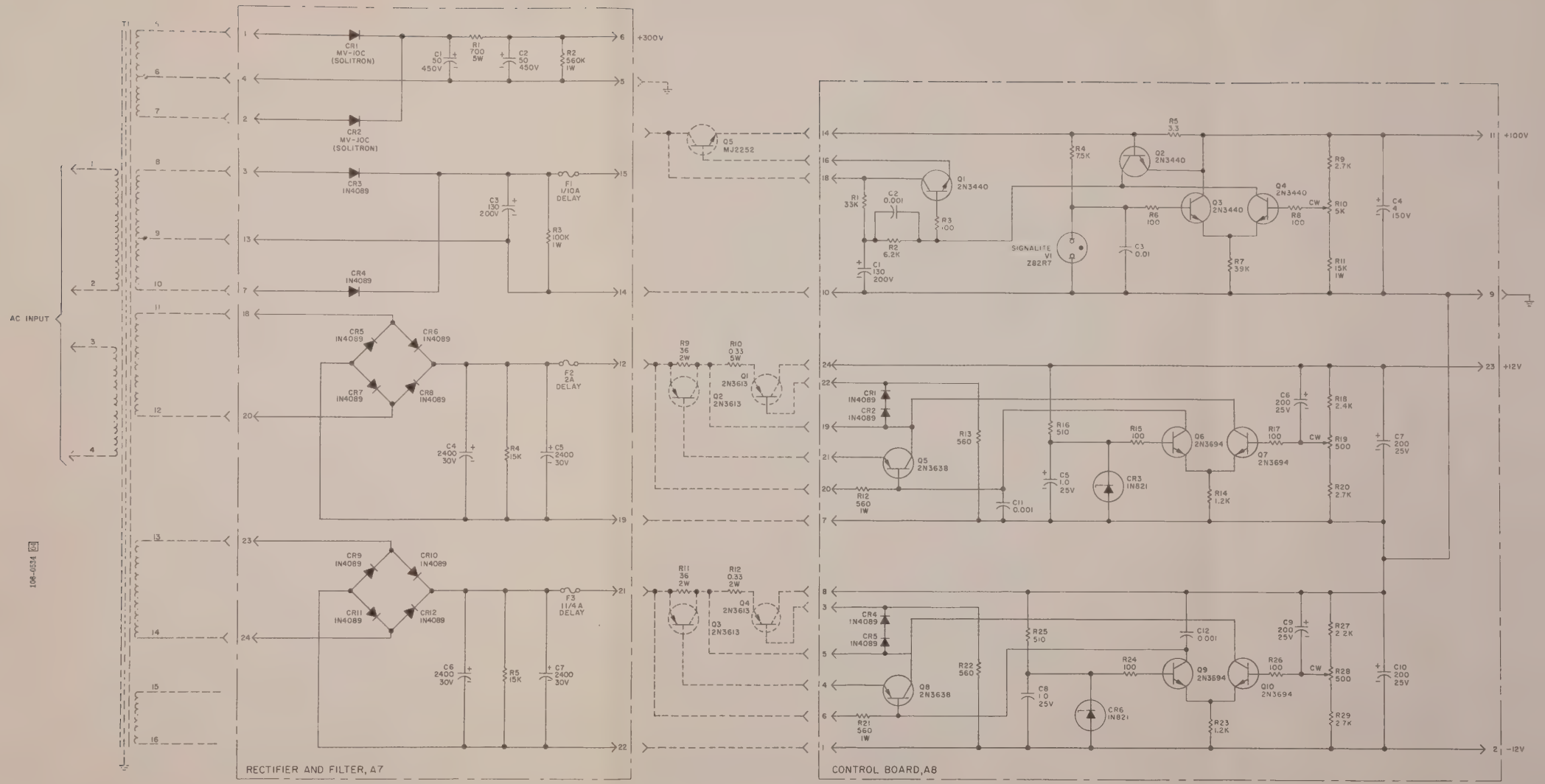


Figure 5-18. High Voltage Power Supply A6, Schematic Diagram



NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%
2. ALL CAPACITORS ARE IN MICROFARADS

Figure 5-19. Power Supply Rectifier/Filter A7 and Power Supply Control A8, Schematic Diagram

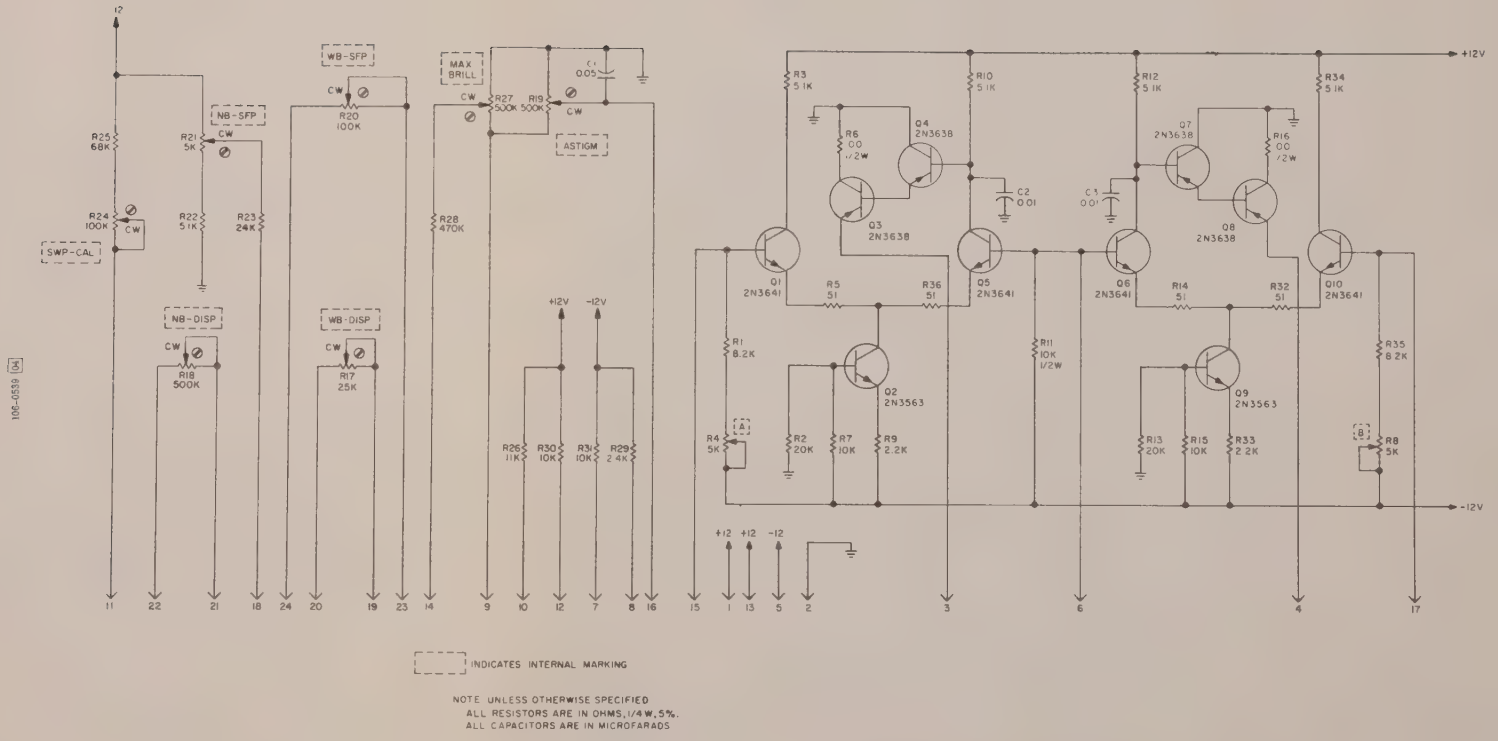


Figure 5-20. Auxiliary Control A9, Schematic Diagram

SECTION VI
PARTS LIST

6-1. INTRODUCTION

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION

6-4. The following instructions will aid in ordering parts from the Parts Lists, tables 6-2 through 6-4.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 50
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut, 06608

b. Include the following information:

1) Model and Serial Number of instrument.

2) Singer Part Number.

3) Reference Symbol Number.

4) Description (as shown on list).

6-5. HOW TO USE THE PARTS LIST

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described; SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

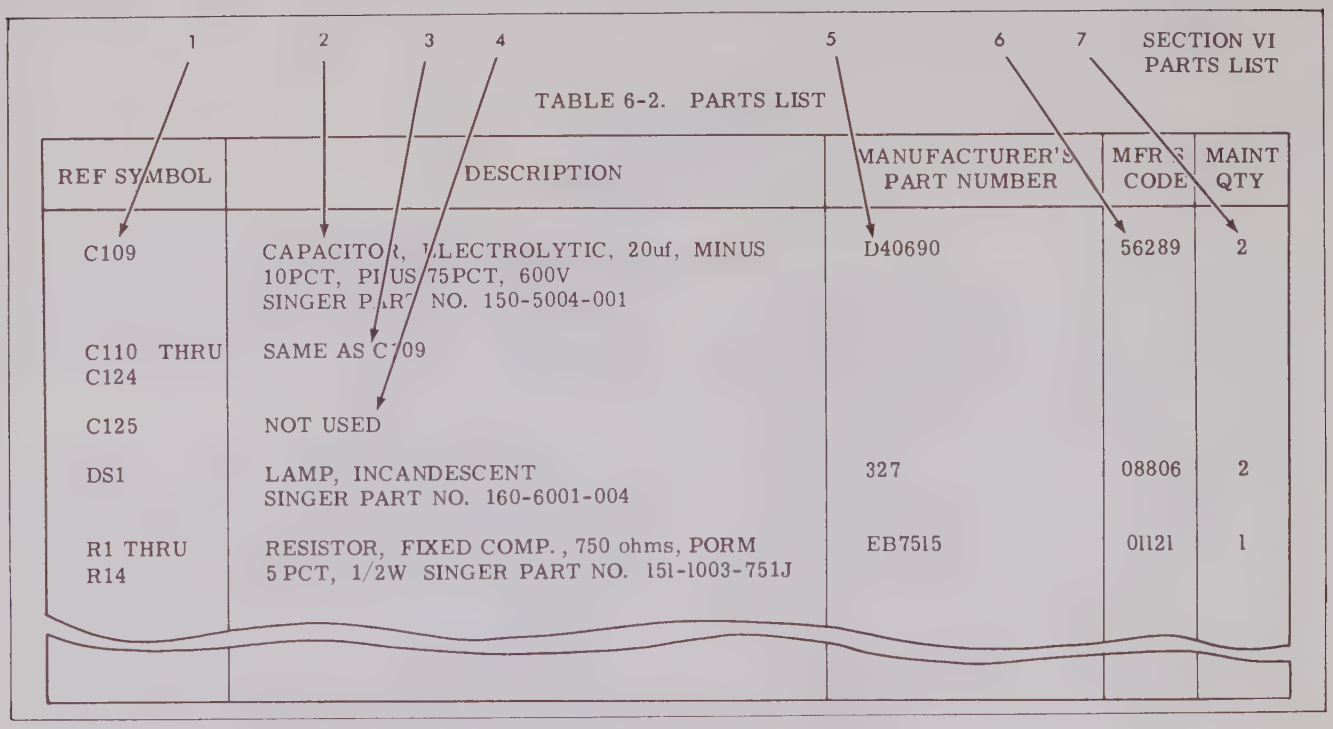


Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name
00656	Aerovox Corp. New Bedford, Mass.
01121	Allen-Bradley Co. Milwaukee, Wisc.
02660	Amphenol-Borg Electronic Corp. Maywood, Ill.
02799	Arco Capacitors, Inc. Los Angeles, Calif.
04213	Caddell-Burns Mfg. Co. Mineola, N.Y.
04713	Motorola Inc. Semiconductor Products Division Pheonix, Arizona
07263	Fairchild Camera and Instrument Corp. Semiconductor Division Mountain View, Calif.
10646	The Carborundum Co. Niagara Falls, N.Y.
11236	CTC of Berne Inc. Berne, Ind.
12126	Kidco Inc. Medford, N.J.
12697	Clarostat Mfg. Co., Inc. Dover, N.H.
13327	Solitron Devices Inc. Tappan, N.Y.
14936	General Instrument Corp. Semi-Conductor Division Hicksville, Long Island, N.Y.
16665	The Singer Company Metrics Division Bridgeport, Conn.
17856	Siliconix Inc. Sunnyvale, Calif.
18736	Voltronic Corp. Hanover, N.J.
19373	Eastron Corp. Haverhill, Mass.
25088	Siemen America Inc. New York, N.Y.
56289	Sprague Electric Co. North Adams, Mass.
63743	Ward Leonard Electric Co. Mount Vernon, N.Y.

TABLE 6-1. MANUFACTURER'S CODE (Cont'd)

Number	Name
71400	Bussmann Mfg. Division of McGraw Edison Company St. Louis, Mo.
71590	Centralab Division of Gloge-Union Inc. Milwaukee, Wisc.
71785	Cinch Mfg. Co. and H.B. Jones Division Chicago, Ill.
72136	Electro-Motive Mfg. Co., Inc. Willimantic, Conn.
72982	Erie Technological Products Inc. Erie, Pa.
74276	Signalite Inc. Neptune, N.J.
74970	E.F. Johnson Co. Waseca, Minn.
75042	International Resistance Co. Philadelphia, Pa.
75915	Littelfuse Inc. Des Plaines, Ill.
78488	Stackpole Carbon Co. St. Marys, Pa.
78526	Stanwyck Winding Co., Inc. Newburgh, N.Y.
81073	Grayhill Inc. La Grange, Ill.
81349	Military Specifications
81483	International Rectifier Corp. El Segundo, Calif.
82389	Switchcraft Inc. Chicago, Ill.
83186	Victory Engineering Corp. Springfield, N.J.
83330	Herman H. Smith, Brooklyn, N.Y.
83701	Electronic Devices Inc. Yonkers, N.Y.
91506	Augat Inc. Attleboro, Mass.
91637	Dale Electronics Inc. Columbus, Nebr.
91833	Keyston Electronics Corp, N.Y., N.Y.
92966	Hudson Lamp Co. Kearny, N.J.
93332	Sylvania Electric Products Inc. Semiconductor Products Division Woburn, Mass.
94144	Raytheon Co. Components Division Quincy, Mass.
95073	Douglas Randall Inc. Westerly, R.I.
95238	Continental Connector Corp. Woodside, N.Y.
95354	Methode Mfg. Co. Chicago, Ill.
98291	Sealectro Corp. Mamaroneck, N.Y.
99517	Vacco Industries El Monte, Calif.
99800	Delevan Electronics Corp. East Aurora, N.Y.

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
CR1	SEMICONDUCTOR DEVICE.DIODE SINGER PART NO. 556146-688	2N821	81349	1
C1	CAPACITOR,FIXED,CERAMIC, 0.001 UF,PORM 10 PCT,1000V SINGER PART NO. 556060-046	DD-102	71590	5
C2	CAPACITOR,FIXED METALIZED PLASTIC, 0.10 UF, PORM 10 PCT,250V SINGER PART NO. 556146-921	B32231-A3104K	25088	1
C3	CAPACITOR,FIXED,METALIZED PLASTIC, 10 UF, PORM 20 PCT, 50V SINGER PART NO. 556146-920	B32110-C9106M	25088	1
C4	SAME AS C1			
C5	CAPACITOR,FIXED,CERAMIC,DISC, 0.02 UF,PORM 20 PCT,1000V SINGER PART NO. 556146-932	CCD-203	02799	1
C6	CAPACITOR,FIXED,DIPPED MICA, 200PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-201EJO	DM15E201J/500WV4CR	72136	1
C7 AND C8	CAPACITOR,FIXED,METALLIZED PAPER, 0.05 UF, PORM 20 PCT,600WVDC SINGER PART NO. 556074-059	P8292ZN27	00656	1
C9	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,PORM 20 PCT,3000VDC SINGER PART NO. 150-1006-001	41C121A2	56289	1
C10	SAME AS C7			
DS1 THRU DS4	LAMP,INCANDESCENT,6.3V SINGER PART NO. 160-6001-002	349	92966	6
E1	CONNECTOR,SECOND ANODE SINGER PART NO. 556023-079	3A1	71785	1
F1 AND F2	FUSE,DELAY, 1 1/4 AMPS SINGER PART NO. 556146-743	MDL1 1/4	71400	8
J1	CONNECTOR,JACK SINGER PART NO. 556146-751	SM11-20SGD	95238	1
J2	CONNECTOR,JACK SINGER PART NO. 556146-755	SM20-20SGD	95238	1
J3	CONNECTOR,JACK, 22 CONTACTS SINGER PART NO. 168-3002-007	71-6022-1100-00	95354	1
J4	CONNECTOR,PRINTED CIRCUIT SINGER PART NO. 168-3002-005	CD615S	95354	1
J5 AND J6	CONNECTOR,JACK SINGER PART NO. 168-3002-008	71-6024-1107-00	95354	1
J7	SAME AS J3			
J8	SAME AS J5			
J9 THRU J11	CONNECTOR,JACK SINGER PART NO. 556147-018	50-010-0000	98291	1
J12 THRU J14	JACK,TIP RED,SINGER PART NO. 556146-912	105-602	74970	1
J15	JACK,TIP BLACK,SINGER PART NO. 556146-913	105-603	74970	1
J16	JACK,TIP VIOLET,SINGER PART NO. 556146-914	105-612	74970	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
K1	RELAY,REED SINGER PART NO. 556146-594	12MM-1C	95073	1
P1	SAME AS J2			
P2	CONNECTOR,PLUG SINGER PART NO. 556146-753	SM14-20SGD	95238	1
P3	CONNECTOR,PLUG, 7 CONTACTS SINGER PART NO. 556016-185	126-196	02660	1
P4 THRU P6	CONNECTOR,COAXIAL SINGER PART NO.556205-007	51-011-0000	98291	1
P7	CONNECTOR,PLUG SINGER PART NO. 556147-021	58-007-0000	98291	1
P8	CONNECTOR,PLUG SINGER PART NO. 556147-020	59-007-0000	98291	1
P9	CONNECOTR,PLUG SINGER PART NO. 556146-754	SM20-20PGD	95238	1
P10	CONNECTOR,PLUG, SINGER PART NO. 168-4031-001	51-007-0000	98291	1
Q1 THRU Q4	TRANSISTOR SINGER PART NO. 556146-678	2N3613	81349	1
Q5	TRANSISTOR SINGER PART NO. 556146-685	MJ2252	04713	1
R1	RESISTOR,VARIABLE,DUAL CONCENTRIC,5K/5K OHMS	132-0268-001	16665	1
R2	RESISTOR,VARIABLE, 1000 OHMS,PORM 10 PCT,2W SINGER PART NO. 151-0007-063	91410	01121	1
R3	RESISTOR,VARIABLE, 10K OHMS,PORM 10 PCT,1/2W SINGER PART NO. 151-0001-055	GA1N044S103UA	01121	1
R4	SAME AS R2			
R5	RESISTOR,VARIABLE, 2.5K OHMS,PORM 20 PCT, 1/2W SINGER PART NO. 151-0001-054	GAIN044S252MA	01121	1
R6	RESISTOR,VARIABLE, 5 MEGOHMS,PORM 10 PCT,2W	149-0069-001	16665	1
R7	RESISTOR,VARIABLE, 500 OHMS,PORM 20 PCT,1/2W SINGER PART NO. 151-0001-053	GAIN044S501MA	01121	1
R8	RESISTOR,VARIABLE, 6 OHMS,PORM 10 PCT, 4W, WITH SWITCH ATTACHED SINGER PART NO. 151-0017-002	CM37449	12697	1
R9	RESISTOR,FIXED,COMP.,360HMS,2W PORM 5PCT SINGER PART NO. 151-1005-360J	HB3605	01121	1
R10	RESISTOR,FIXED,WIRE-WOUND, 0.33 OHMS,PORM 10 PCT,2W SINGER PART NO. 556146-922	BWH-0.330HMPORM10PCT	75042	1
R11	SAME AS R9			
R12	SAME AS R10			
R13	RESISTOR,FIXED,COMP., 3000 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-302J	CB3025	01121	5
R14	PART OF S3			
R15	RESISTOR,FIXED,DEPOSITED CARBON, 3.01K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3011F	C1/8E30100HMPORM1PCT	12126	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R16	RESISTOR,FIXED,DEPOSITED CARBON, 30.1K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3012F	C1/8E30100 PORM1PCT	12126	1
R17	RESISTOR,FIXED,DEPOSITED CARBON, 10 K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1002F	C1/8R10KOHMPORM1PCT	12126	1
R18	RESISTOR,FIXED,DEPOSITED CARBON, 100K OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1003F	C1/8E104OHMPORM1PCT	12126	1
R19	RESISTOR,FIXED,COMP.,1000 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	8
R20	PART OF S5			
R21	PART OF S4			
R22	RESISTOR,FIXED,COMP., 5100 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-512J	CB5125	01121	4
R23	RESISTOR,FIXED,COMP., 8200 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-822J	CB8225	01121	1
R24	RESISTOR,FIXED,COMP., 56K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-563J	CB5635	01121	2
R25	RESISTOR,FIXED,COMP., 30K OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-303J	CB3035	01121	1
R26	PART OF S2			
R27	SAME AS R19			
R28	RESISTOR,FIXED,COMP., 10K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-103J	CB1035	01121	3
R29	SAME AS R22			
R30 AND R31	SAME AS R19			
R32	RESISTOR,FIXED,COMP., 33K OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-333J	CB3335	01121	2
R33A AND R33B	PART OF S1			
R34	RESISTOR,FIXED,WIRE-WOUND, 12 MEGOHM,PORM 20 PCT,1W SINGER PART NO. 556146-910	MVX/12MEGPORM20PCT1W	75042	1
R35	RESISTOR,FIXED,COMP., 51K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-513J	CB5135	01121	2
R36	PART OF S6			
R37	RESISTOR,FIXED,DEPOSITED CARBON, 5490 OHMS PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B5491F	C1/8E5490OHMPORM1PCT	12126	1
R38	RESISTOR,FIXED,DEPOSITED CARBON, 1740 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1741F	C1/8E1740OHMPORM1PCT	12126	1
R39	RESISTOR,VARIABLE, 800 OHMS TO 1.2K OHMS SINGER PART NO. 556147-193	VR025-1001	99517	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R40	RESISTOR,FIXED,DEPOSITED CARBON, 49.9 OHMS PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B49R9F	C1/8E49.9OHMPORM1PCT	12126	1
R41	RESISTOR,FIXED,DEPOSITED CARBON, 100 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1000F	C1/8E100OHMPORM1PCT	12126	1
R42	RESISTOR,FIXED,DEPOSITED CARBON, 348 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3480F	C1/8E348OHMPORM1PCT	12126	1
R43	RESISTOR,FIXED,DEPOSITED CARBON, 1020 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1021F	C1/8E1020OHMPORM1PCT	12126	1
R44	RESISTOR,FIXED,DEPOSITED CARBON, 3650 OHMS PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B3651F	C1/8E3650OHMPORM1PCT	12126	1
R45	RESISTOR,FIXED,DEPOSITED CARBON, 9760 OHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B9761F	C1/8E9760OHMPORM1PCT	12126	1
R46	RESISTOR,FIXED,DEPOSITED CARBON, 499 OHMS, PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B4990F	C1/8E499PORM1PCT	12126	1
R47	RESISTOR,FIXED,DEPOSITED CARBON, 1.82 KOHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1821F	C1/8E1820PORM1PCT	12126	1
R48	RESISTOR,FIXED,DEPOSITED CARBON, 11.5 KOHMS, PORM 1 PCT,1/8W SINGER PART NO. 151-1006-B1152F	C1/8E11500PORM1PCT	12126	1
R49	RESISTOR,FIXED,COMP., 39 KOHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-393J	CB3935	01121	1
R50	RESISTOR,FIXED,COMP., 51 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-510J	CB5105	01121	2
R51	SAME AS R19			
R52	RESISTOR,VARIABLE, 8K TO 12K, 1/4W SINGER PART NO. 556147-063	VR025-1002	99517	1
R53 AND R54	SAME AS R22			
R55	RESISTOR,FIXED,COMP.,15KOHMS,PORM 5PCT., 1/4W SINGER PART NO. 151-1002-153J	CB1535	01121	1
R56	RESISTOR,FIXED,DEPOSITED CARBON, 150 OHMS, PORM 1 PCT,1/4W SINGER PART NO. 151-1006-B1500F	C1/8E150PORM1PCT	12126	1
S1	SWITCH AND POT ASSY, BANDWIDTH	133-0107-001	16665	1
S2	SWITCH AND POT ASSY SWEEP	133-0089-001	16665	1
S3	SWITCH AND POT ASSY SWP/SYNC	133-0088-001	16665	1
S4	SWITCH AND POT ASSY MARKER MODULATION	133-0073-001	16665	1
S5	SWITCH AND POT ASSY AMPLSCALE	133-0077-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
S6	SWITCH AND POT ASSY FREQ DISPERSION	133-0083-001	16665	1
S7	SWITCH,NON-REPLACEABLE PART OF R8			
S9	SWITCH,SLIDE, DPDT SINGER PART NO. 556146-590	46206LF	82389	1
S10	SWITCH,PUSH BUTTON,SPST SINGER PART NO. 556146-736	30-1	81073	1
T1	TRANSFORMER,POWER	132-0201-001	16665	1
V1	TUBE,CRT SINGER PART NO. 556146-902	5ADP31M	81349	1
W1	CABLE ASSY	102-9200-320	16665	1
W1P1	SAME AS P7			
W1P2	SAME AS P10			
W2	CABLE ASSEMBLY	102-9111-011	16665	1
W2P1 AND P2	SAME AS P10			
W3	CABLE ASSY	102-9200-360	16665	1
W3P1 AND P2	CONNECTOR,PLUG SINGER PART NO. 556147-019	50-011-0000	98291	1
W4	CABLE ASSEMBLY	102-9200-370	16665	1
W4P1 AND P2	SAME AS P7			
XF1 AND XF2	HOLDER,FUSE SINGER PART NO. 556006-072	341001	75915	1
XV1	SOCKET,TUBE	556024-047	16665	1
A1	I-F ATTENUATOR ASSY	103-1587-001	16665	1
A1J1 THRU J4	CONNECTOR ASSY	133-0070-001	16665	1
A1R1	RESISTOR,FIXED,FILM, 96.250HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-016	DC1/10-96.25PORM1PCT	91637	1
A1R2	RESISTOR,FIXED,FILM 71.15 OHMS,PORM 1PCT, 1/10W, NON-HELIXED SINGER PART NO.556204-015	DC1/10-71.15PORM1PCT	91637	1
A1R3	SAME AS A1R1			
A1R4	RESISTOR,FIXED,FILM, 61.110HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-013	DC1/10-61.11PORM1PCT	91637	1
A1R5	RESISTOR,FIXED,FILM, 247.50HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-023	DC1/10-247.5PORM1PCT	91637	1
A1R6	SAME AS A1R4			
A1R7	RESISTOR,FIXED,FILM, 53.270HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-012	DC1/10-53.27PORM1PCT	91637	1
A1R8	RESISTOR,FIXED,FILM, 790.00HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-026	DC1/10-790.0PORM1PCT	91637	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1R9	SAME AS A1R7			
A1R10	RESISTOR,FIXED,FILM, 51.01OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-010	DC1/10-51.01PORM1PCT	91637	1
A1R11	RESISTOR,FIXED,FILM, 2500 OHMS,PORM 1 PCT, 1/8W,NON-HELIXED SINGER PART NO. 556204-100	DC1/8-2500PORM1PCT	91637	1
A1R12	SAME AS A1R10			
A1R13	RESISTOR,FIXED,FILM, 50.32OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-009	DC1/10-50.32PORM1PCT	91637	1
A1R14	RESISTOR,FIXED,FILM, 7910 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-101	DC1/8-7910PORM1PCT	91637	1
A1R15	SAME AS A1R13			
A1R16	RESISTOR,FIXED,FILM, 50.1 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-008	DC1/10-50.1 PORM1PCT	91637	1
A1R17 AND R18	RESISTOR,FIXED,COMP., 12K OHMS,PORM 5 PCT, 1/8W SINGER PART NO. 556146-763	BB1235	01121	1
A1R19	SAME AS A1R16			
A1R20	RESISTOR,FIXED,FILM, 870.00HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-027	DC1/10-870.0PORM1PCT	91637	1
A1R21	RESISTOR,FIXED,FILM, 5.77 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-001	DC1/10-5.77 PORM1PCT	91637	1
A1R22	SAME AS A1R20			
A1R23	RESISTOR,FIXED,FILM, 436.20HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-025	DC1/10-436.2PORM1PCT	91637	1
A1R24	RESISTOR,FIXED,FILM, 11.610HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-002	DC1/10-11.61PORM1PCT	91637	1
A1R25	SAME AS A1R23			
A1R26	RESISTOR,FIXED,FILM, 292.40HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-024	DC1/10-292.4PORM1PCT	91637	1
A1R27	RESISTOR,FIXED,FILM, 17.610HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-003	DC1/10-17.61PORM1PCT	91637	1
A1R28	SAME AS A1R26			
A1R29	RESISTOR,FIXED,FILM, 221.00HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-022	DC1/10-221.0PORM1PCT	91637	1
A1R30	RESISTOR,FIXED,FILM, 23.850HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-004	DC1/10-23.85PORM1PCT	91637	1
A1R31	SAME AS A1R29			
A1R32	RESISTOR,FIXED,FILM, 178.50HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO.556204-021	DC1/10-178.5PORM1PCT	91637	1
A1R33	RESISTOR,FIXED,FILM, 30.4 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-005	DC1/10-30.4 PORM1PCT	91637	1
A1R34	SAME AS A1R32			
A1R35	RESISTOR,FIXED,FILM, 150.50HMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-020	DC1/10-150.5PORM1PCT	91637	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1R36	RESISTOR,FIXED,FILM, 37.35OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-006	DC1/10-37.35PORM1PCT	91637	1
A1R37	SAME AS A1R35			
A1R38	RESISTOR,FIXED,FILM, 130.7OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-01	DC1/10-130.7PORM1PCT	91637	1
A1R39	RESISTOR,FIXED,FILM, 44.8 OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-007	DC1/10-44.8 PORM1PCT	91637	1
A1R40	SAME AS A1R38			
A1R41	RESISTOR,FIXED,FILM, 116.1OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-018	DC1/10-116.1PORM1PCT	91637	1
A1R42	RESISTOR,FIXED,FILM, 52.84OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-011	DC1/10-52.84PORM1PCT	91637	1
A1R43	SAME AS A1R41			
A1R44	RESISTOR,FIXED,FILM, 105.0OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-017	DC1/10-105.0PORM1PCT	91637	1
A1R45	RESISTOR,FIXED,FILM, 61.59OHMS,PORM 1 PCT, 1/10W,NON-HELIXED SINGER PART NO. 556204-014	DC1/10-61.59PORM1PCT	91637	1
A1R46	SAME AS A1R44			
A1W4	CABLE ASSY	102-9200-370	16665	1
A1W4P1 AND P2	SAME AS P7		98291	1
A2	FRONT IF ASSY	103-1584-002	16665	1
A2C1 AND C2	CAPACITOR,FIXED,FEED-THRU, 1000 PF,PORM 20 PCT,500V SINGER PART NO. 556146-899	2499-003-X5S0-102M	72982	1
A2C6 THRU C8	SAME AS A2C1			
A2C10 AND C11	SAME AS A2C1			
A2C13 THRU C23	SAME AS A2C1			
A2FL1 THRU FL3	FILTER,FEED-THRU, 5000 PF SINGER PART NO. 556146-774	1270-016	72982	10
A2J1	SAME AS P9			
A2J2 THRU J4	CONNECTOR, JACK SINGER PART NO. 168-4034-001	51-010-0000	98291	1
A2P1	CONNECTOR,PLUG, 2 TERMINALS	128-1036-010	16665	1
A2P2	CONNECTOR,PLUG, 4 TERMINALS	128-1036-004	16665	1
A2P3	CONNECTOR,PLUG, 2 TERMINALS	128-1036-009	16665	1
A2P4	CONNECTOR,PLUG, 2 TERMINALS	128-1036-008	16665	1
A2P5	CONNECTOR,PLUG, 4 TERMINALS	128-1036-002	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2P6	CONNECTOR,PLUG, 6 TERMINALS	128-1036-003	16665	1
A2P7	CONNECTOR,PLUG, 4 TERMINALS	128-1036-005	16665	1
A2P8	CONNECTOR,PLUG, 3 TERMINALS	128-1037-002	16665	1
A2P9 THRU P11	CONNECTOR, PLUG, PHONO SINGER PART NO. 556147-239	202-19-01-092	71785	1
A2W1	CABLE ASSY	102-9200-415	16665	1
A2W1P1 AND P2	SAME AS A2P9	202-19-01-092	71785	1
A2W2	CABLE ASSY	102-9200-410	16665	1
A2W2P1 AND P2	SAME AS A2P9			
A2W4	CABLE ASSY	102-9200-431	16665	1
A2W4P1 AND P2	SAME AS A2P9			
A2W5 AND W6	CABLE ASSY	102-9200-430	16665	1
A2W5P1 AND P2	SAME AS A2P9			
A2W6P1 AND P2	SAME AS A2P9			
A2W7	CABLE ASSY	102-9200-432	16665	1
A2W7P1 AND P2	SAME AS A2P9			
A2W8	CABLE ASSY	102-9200-416	16665	1
A2W8P1 AND P2	SAME AS A2P9			
A2W9	CABLE ASSY	102-9200-417	16665	1
A2W9P1 AND P2	SAME AS A2P9			
A2A1	MARKER OSCILLATOR ASSY	103-1552-002	16665	1
A2A1CR1 THRU CR4	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-041	IN34A	93332	1
A2A1C1 AND C2	SAME AS C1			
A2A1C3	CAPACITOR,FIXED,COMP., 1.5 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-1R5J	GA1.5PFPORMKPCT	78488	1
A2A1C4	CAPACITOR,FIXED,DIPPED MICA, 27 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-270EJ0	DM15E270J0500WV4CR	72136	1
A2A1C5	CAPACITOR,VARIABLE, 2 TO 8 PF SINGER PART NO. 150-0008-001	538-011A2-8	72982	1
A2A1C6 AND C7	SAME AS C1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A1C8	CAPACITOR,FIXED,CERAMIC, 0.1 UF,PORM 20 PCT, 25V SINGER PART NO. 556120-162	5C023104X0250B3	56289	1
A2A1C9	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,PLUS 60 MINUS 40 PCT,250V SINGER PART NO. 556060-146	DA140-1728	71590	3
A2A1C10	SAME AS A2A1C3			
A2A1C11	CAPACITOR,FIXED,COMP., 1.0 PF,PORM 10 PCT, 500V SINGER PART NO. 150-4001-1R0K	GA1PFPORM10PCT	78488	1
A2A1C12	CAPACITOR,VARIABLE, 7 TO 25 PF SINGER PART NO. 150-0008-004	538-011B7-25	72982	1
A2A1C13	SAME AS C1			
A2A1C14	CAPACITOR,FIXED,DIPPED MICA, 50 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-500EJ0	DM15E500J0500WV4CR	72136	1
A2A1C15	SAME AS A2A1C9			
A2A1C16	CAPACITOR,FIXED,COMP., 2.2 PF,PORM 10 PCT, 500V SINGER PART NO. 150-4001-2R2K	GA2.2PFPORM10PCT	78488	1
A2A1C17	SAME AS A2A1C8			
A2A1C18	CAPACITOR,FIXED,DIPPED MICA, 510PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-511EJ0	DM15E511J0500WV4CR	72136	1
A2A1C19	CAPACITOR,VARIABLE, 9 TO 35 PF SINGER PART NO. 150-0008-008	538-011D9-35	72982	1
A2A1C20	CAPACITOR,FIXED,DIPPED MICA, 10 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-100EJ0	DM15E100J0500WV4CR	72136	1
A2A1C21	CAPACITOR,FIXED,DIPPED MICA, 470PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-471EJ0	DM15E471J0500WV4CR	72136	1
A2A1C22	SAME AS A2A1C8			
A2A1C23	SAME AS C1			
A2A1J1	CONNECTOR, JACK, PHONO SINGER PART NO. 556024-272	1233	83330	1
A2A1L1	INDUCTOR	132-0242-001	16665	1
A2A1L2	INDUCTOR	132-0243-001	16665	1
A2A1L3	INDUCTOR	132-0241-001	16665	1
A2A1L4	INDUCTOR	132-0237-001	16665	1
A2A1L5	INDUCTOR	132-0238-001	16665	1
A2A1L6	INDUCTOR,SHIELDED, 100 UH SINGER PART NO. 556200-010	DINK-100	78526	1
A2A1Q1 THRU Q3	TRANSISTOR SINGER PART NO. 556146-251	2N3563	14936	2
A2A1Q4	TRANSISTOR SINGER PART NO. 556146-254	2N3565	07263	1
A2A1R1	RESISTOR,FIXED,COMP., 100 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-101J	CB1015	01121	5

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A1R2	SAME AS R19			
A2A1R3	SAME AS A2A1R1			
A2A1R4 AND R5	SAME AS R19			
A2A1R6	RESISTOR,FIXED,COMP., 150 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-151J	CB1515	01121	4
A2A1R7	RESISTOR,FIXED,COMP., 39 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-390J	CB3905	01121	1
A2A1R8	SAME AS A2A1R6			
A2A1R9	RESISTOR,FIXED,COMP., 330 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-331J	CB3315	01121	2
A2A1R10 AND R11	RESISTOR,FIXED,COMP., 12K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-123J	CB1235	01121	4
A2A1R12	RESISTOR,FIXED,COMP., 68 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-680J	CB6805	01121	1
A2A1R13	RESISTOR,FIXED,COMP., 240 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-241J	CB2415	01121	1
A2A1R14 AND R15	RESISTOR,FIXED,COMP., 22K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-223J	CB2235	01121	1
A2A1R16	RESISTOR,FIXED,COMP., 3900 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-392J	CB3925	01121	1
A2A1R17	RESISTOR,FIXED,COMP., 1.8K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-182J	CB1825	01121	2
A2A1R18 AND R19	SAME AS A2A1R14			
A2A1R20	SAME AS A2A1R16			
A2A1R21	SAME AS A2A1R13			
A2A1T1	TRANSFORMER	132-0235-001	16665	1
A2A1T2	TRANSFORMER,RF	132-0234-001	16665	1
A2A2	MARKER LEVEL ASSY	103-1553-002	16665	1
A2A2CR1 AND CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-880	FDH-666	07263	1
A2A2C1 THRU C3	SAME AS C1			
A2A2J1 AND J2.	SAME AS A2A1J1			
A2A2R1	SAME AS R19			
A2A2R2	SAME AS A2A1R1			
A2A2R3	SAME AS R19			
A2A3	160-MHZ WIDEBAND AMPLIFIER ASSY	103-1554-002	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A3C1	CAPACITOR,FIXED,COMP., 6.8 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-6R8J	GA6.8PFPORM5PCT	78488	1
A2A3C2	CAPACITOR,VARIABLE, 2.5PF TO 11PF SINGER PART NO. 150-0008-003	538-011B2.5.11	72982	1
A2A3C3	SAME AS C1			
A2A3C4 AND C5	CAPACITOR,FIXED,CERAMIC DISC, 470 PF,PORM 10 PCT,1000V SINGER PART NO. 556146-695	DD471	71590	1
A2A3C6	CAPACITOR,FIXED,DIPPED MICA, 250PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-251EJO	DM15E251JO500WV4CR	72136	1
A2A3C7	SAME AS A2A3C4			
A2A3C8	CAPACITOR,FIXED,DIPPED MICA, 36 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-360EJO	DM15E360JO500WV4CR	72136	1
A2A3C9	SAME AS A2A3C6			
A2A3C10 AND C11	SAME AS A2A3C4			
A2A3C12	SAME AS A2A3C6			
A2A3C13	SAME AS A2A3C4			
A2A3C14	SAME AS C1			
A2A3C15 AND C16	SAME AS A2A3C4			
A2A3C17 AND C18	SAME AS A2A1C5			
A2A3J1 THRU J3	SAME AS A2A1J1			
A2A3L1	INDUCTOR	132-0322-001	16665	1
A2A3L2	INDUCTOR,VARIABLE	132-0312-001	16665	1
A2A3L3	INDUCTOR,VARIABLE	132-0226-001	16665	1
A2A3L4	COIL,RF,0.68 UH SINGER PART NO. 556012-013	CLA-0.68PORM10PCT	75042	1
A2A3L5	CHOKE,RF,1UH SINGER PAWRT NO. 556012-147	2150-04	99800	1
A2A3L6	INDUCTOR	132-0323-001	16665	1
A2A3Q1 THRU Q4	TRANSISTOR SINGER PART NO. 556147-178	S24058	07263	1
A2A3R1 AND R2	RESISTOR,FIXED,COMP., 8.2 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-8R2J	CB8R25	01121	1
A2A3R3	RESISTOR,FIXED,COMP.,150 OHMS,PORM 5PCT 1/4W SINGER PART NO. 151-1002-151J	CB1525	01121	1
A2A3R4	SAME AS A2A1R17			
A2A3R5	RESISTOR,FIXED,COMP., 680 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-681J	CB6815	01121	1
A2A3R6	RESISTOR,FIXED,COMP., 390 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-391J	CB3915	01121	2

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A3R7	RESISTOR,FIXED,COMP., 360 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-361J	CB3615	01121	2
A2A3R8	RESISTOR,FIXED,COMP., 18 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-180J	CB1805	01121	1
A2A3R9	RESISTOR,FIXED,COMP., 1.5K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	CB1525	01121	4
A2A3R10	RESISTOR,FIXED,COMP., 300 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-301J	CB3015	01121	1
A2A3R11	SAME AS A2A3R6			
A2A3R12	RESISTOR,FIXED,COMP.,91 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-910J	CB9105	01121	1
A2A3R13	SAME AS A2A3R7			
A2A3R14	SAME AS A2A3R8			
A2A3R15	SAME AS A2A1R6			
A2A3R16	RESISTOR,FIXED,COMP.,390 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-391J	CB3915	01121	1
A2A3R17	SAME AS A2A3R7			
A2A3R18	SAME AS A2A3R12			
A2A3R19	SAME AS A2A3R8			
A2A3R20	SAME AS A2A1R6			
A2A3R21 AND R22	SAME AS A2A3R7			
A2A3R23	SAME AS A2A3R12			
A2A3R24	RESISTOR,FIXED,COMP., 470 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-471J	CB4715	01121	1
A2A4	HIGH-PASS FILTER ASSY	103-1555-002	16665	1
A2A4C1	SAME AS A2A1C20			
A2A4C2	CAPACITOR,FIXED,DIPPED MICA, 20 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-200EJ0	DM15E200J0500WV4CR	72136	1
A2A4C3	CAPACITOR,FIXED,DIPPED MICA, 39 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-390EJ0	DM15E390J0500WV4CR	72136	1
A2A4C4	CAPACITOR,VARIABLE, 5.5 TO 18 PF,350V SINGER PART NO. 151-0004-002	538-006CP092R	72982	1
A2A4C5	SAME AS A2A4C2			
A2A4J1 AND J2	CONNECTOR, JACK, PHONO, RT ANGLE SINGER PART NO. 556147-238	571	91833	1
A2A4L1 AND L2	INDUCTOR	132-0245-001	16665	1
A2A4R1	RESISTOR,FIXED,COMP., 560 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-561J	CB5615	01121	3

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A4R2	RESISTOR,FIXED,COMP., 30 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-300J	CB3005	01121	2
A2A4R3	SAME AS A2A4R1			
A2A4R4	SAME AS A2A4R2			
A2A4R5	RESISTOR,FIXED,COMP., 120 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-121J	CB1215	01121	1
A2A4R6	SAME AS A2A4R2			
A2A5	LOW-PASS FILTER ASSY	103-1556-002	16665	1
A2A5C1	CAPACITOR,FIXED,COMP., 4.7PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-4R7J	GA4.7PFPORM5PCT	78488	1
A2A5C2 AND C3	CAPACITOR,VARIABLE, 0.8 TO 4.5PF SINGER PART NO. 150-0010-001	V1270	18736	
A2A5C4	CAPACITOR,FIXED,COMP., 1.8 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-1R8J	GA1.8PFPORM5PCT	78488	1
A2A5C5	SAME AS A2A5C2			
A2A5J1 AND J2	SAME AS A2A4J1			
A2A5L1	INDUCTOR	132-0246-001	16665	1
A2A5L2	INDUCTOR	132-0247-001	16665	1
A2A5L3	INDUCTOR	132-0248-001	16665	1
A2A5L4	INDUCTOR	132-0249-001	16665	1
A2A5L5	SAME AS A2A5L3			
A2A5L6	SAME AS A2A5L4			
A2A5L7	SAME AS A2A5L1			
A2A6	LOW-PASS FILTER ASSY	103-1557-002	16665	1
A2A6C1	SAME AS A2A1C16			
A2A6C2	SAME AS A2A5C2			
A2A6C3	SAME AS A2A1C16			
A2A6C4	SAME AS A2A5C2			
A2A6C5	CAPACITOR,FIXED,COMP., 10 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-100J	GA10PFPORM5PCT	78488	1
A2A6J1 AND J2	SAME AS A2A4J1			
A2A6L1	INDUCTOR	132-0252-001	16665	1
A2A6L2 AND L3	SAME AS A2A5L1			
A2A6L4	SAME AS A2A5L4			
A2A6L5	SAME AS A2A5L1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A6R1	SAME AS A2A3R9			
A2A6R2	RESISTOR,FIXED,COMP., 10 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-100J	CB1005	01121	1
A2A6R3	SAME AS A2A3R9			
A2A6R4	SAME AS A2A4R1			
A2A6R5	SAME AS A2A4R2			
A2A6R6	SAME AS A2A4R1			
A2A7	WIDEBAND/NARROWBAND SWEPT OSCILLATOR ASSY	103-1558-002	16665	1
A2A7CR1 THRU CR4	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-687	1N82AG	81349	1
A2A7CR5	SAME AS A2A2CR1			
A2A7CR6	SEMICONDUCTOR DEVICE.DIODE SINGER PART NO. 556147-023	1N942A	81349	1
A2A7C1	CAPACITOR,FIXED,CERAMIC, 0.47 UF,PORM 20 PCT 25V SINGER PART NO.556120-160	5C11	56289	3
A2A7C2 THRU C4	CAPACITOR,FIXED,ELECTROLYTIC, 10 UF,PLUS 75 MINUS 10 PCT,15V SINGER PART NO. 150-5001-100DS	TE-1155	56289	1
A2A7C5	CAPACITOR,FIXED,FEED-THRU, 1000 PF,PORM 20 PCT,300V SINGER PART NO. 556147-112	FW5N/1000PF,W/M-6447	01121	1
A2A7C6	CAPACITOR,FIXED,COMP. 0.82PF PORM 10PCT 500V SINGER PART NO. 150-4001-R82K	GA0.82PFPORM10PCT	78488	1
A2A7C7	CAPACITOR,FIXED,COMP., 1 PF,PORM 5 PCT,500V SINGER PART NO. 150-4001-1R0J	GA1.0PFPORM5PCT	78488	1
A2A7C8	SAME AS A2A1C5			
A2A7C9 AND C10	SAME AS C1			
A2A7C11	SAME AS A2A1C19			
A2A7C12	SAME AS A2A3C8			
A2A7C13	CAPACITOR,FIXED,DIPPED MICA, 30 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-300EJ0	DM15E300J0500WV4CR	72136	1
A2A7C14	SAME AS C1			
A2A7C15	SINGER PART NO. 150-4001-2R4J	GA2.4 PF,PORM 5 PCT	78488	
A2A7C16	CAPACITOR,FIXED,DISC 200PF PORM 10PCT 1KV SINGER PART NO. 556146-696	DD-201	71590	1
A2A7C17	SAME AS C1			
A2A7C18	SAME AS A2A7C2			
A2A7C19	CAPACITOR,FIXED,DIPPED MICA, 15 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-150EJ0	DM15E150J0500WV4CR	72136	1
A2A7C20	CAPACITOR,VARIABLE, 47 PF,PORM 20 PCT,80V SINGER PART NO. 556146-095	VC347	19373	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A7C21	CAPACITOR,FIXED,COMP., 7.5 PF,PORM 5 PCT, 500V SINGER PART NO. 150-4001-7R5J	GA7.5PFPORM5PCT	78488	1
A2A7C22 AND C23	SAME AS C1			
A2A7C24	CAPACITOR FIXED, 0.01UF SINGER PART NO. 556060-146	DA140-172B	71590	1
A2A7C25	CAPACITOR,FIXED,ELECTROLYTIC, 10 UF,PLUS 75 MINUS 10 PCT,100V SINGER PART NO. 150-5001-100GS	TE-1407	56289	
A2A7C26 AND C27	SAME AS C1			
A2A7C28	SAME AS A2A7C2			
A2A7J1 AND J2	SAME AS A2A1J1			
A2A7L1 THRU L3	CHOKE,SHIELDED, 5 MH SINGER PART NO. 556147-022	670-5	04213	1
A2A7L4	INDUCTOR,CURRENT CONTROL	132-0221-001	16665	1
A2A7L5	COIL	132-0239-001	16665	1
A2A7L6	SAME AS A2A7L1			
A2A7Q1	TRANSISTOR SINGER PART NO. 556146-676	2N3642	81349	1
A2A7Q2	TRANSISTOR	132-0317-001	16665	1
A2A7Q3	SAME AS A2A1Q1			
A2A7Q4	TRANSISTOR SINGER PART NO. 556146-680	2N3932	81349	1
A2A7Q5	SAME AS A2A1Q1			
A2A7Q6	TRANSISTOR SINGER PART NO. 556146-682	SE-7010	07263	1
A2A7Q7	TRANSISTOR SINGER PART NO. 556146-254	2N3565	07263	1
A2A7RV1	VARISTOR, 6V TO 11V SINGER PART NO. 556052-059	114W3	83186	1
A2A7RV2	VARISTOR, 10V,PORM 30 PCT AT 5 MA SINGER PART NO. 556146-738	063L9	83186	1
A2A7R1	SAME AS R35			
A2A7R2	SAME AS R32			
A2A7R3	RESISTOR,FIXED,COMP., 150K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-154J	CB1545	01121	1
A2A7R4	RESISTOR,FIXED,COMP., 2K OHM,PORM 5 PCT,1/4W SINGER PART NO. 151-1002-202J	CB2025	01121	1
A2A7R5	SAME AS A2A1R1			
A2A7R6	SAME AS R22			
A2A7R7	RESISTOR,FIXED,COMP., 68K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-683J	CB6835	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A7R8	RESISTOR,VARIABLE, 2.8 KOHMS,1/4W SINGER PART NO. 556197-194	VR025-2801	99517	1
A2A7R9	RESISTOR,VARIABLE, 250 OHMS,W.W. SINGER PART NO. 556146-764	115/250OHMS	11236	1
A2A7R10	RESISTOR,FIXED,COMP., 10 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-100J	EB1005	01121	1
A2A7R11	SAME AS A2A1R1			
A2A7R12	SAME AS A2A1R17			
A2A7R13	RESISTOR,FIXED,COMP., 430 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-431J	CB4315	01121	1
A2A7R14	RESISTOR,VARIABLE, 500 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-002	UHT201-2/50020,PCT	11236	1
A2A7R15 AND R16	RESISTOR,FIXED,COMP., 18K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-183J	CB1835	01121	4
A2A7R17	SAME AS A2A4R1			
A2A7R18	SAME AS R19			
A2A7R19	RESISTOR,FIXED,COMP. 2.4K OHMS,PORM 5PCT 1/4W SINGER PART NO. 150-1002-242J	CB2425	01121	1
A2A7R20	RESISTOR,FIXED,COMP., 100K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-104J	CB1045	01121	1
A2A7R21	SAME AS R50			
A2A7R22	RESISTOR,FIXED,COMP., 10K OHMS ,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-103J	EB1035	01121	1
A2A7R23	SAME AS R35			
A2A7R24	SAME AS R19			
A2A7R25	RESISTOR,VARIABLE, 10K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-006	UHT201-2/10K,20PCT	11236	1
A2A7R26	RESISTOR,FIXED,COMP., 91K OHMS ,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-913J	EB9135	01121	1
A2A7R27	SAME AS R32			
A2A7R28	SAME AS A2A1R17			
A2A7R29	RESISTOR,FIXED,COMP.,3.6K OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-362J	CB3625	01121	1
A2A7R30	SAME AS R32			
A2A7R31	RESISTOR,FIXED,COMP., 12K OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-123J	GB1235	01121	1
A2A7R32	RESISTOR,FIXED,COMP., 15 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-150J	CB1505	01121	1
A2A7T1	TRANSFORMER	132-0267-001	16665	1
A2A7T2	TCRIOD	132-0261-001	16665	1
A2A7T3	TRANSFORMER,VARIABLE	132-0227-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A8	60-MHZ IF AMPLIFIER ASSY	103-1559-002	16665	1
A2A8C1	CAPACITOR,FIXED,DIPPED MICA, 100PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-101EJ0	DM15E101H0500WV4CR	72136	1
A2A8C2	CAPACITOR,FIXED,DIPPED MICA 56 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-560EJ0	DM15E560J0500WV4CR	72136	1
A2A8C3 AND C4	SAME AS C1			
A2A8C5	SAME AS A2A8C1			
A2A8C6	CAPACITOR,FIXED,DIPPED MICA, 22 PF, PORM 5 PCT,500V SINGER PART NO. 150-2002-220EJ0	DM15E220J0500WV4CR	72136	1
A2A8C7 THRU C15	SAME AS C1			
A2A8C16	CAPACITOR,FIXED,DIPPED MICA, 33 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-330EJ0	DM15E330J0500WV4CR	72136	1
A2A8C17	CAPACITOR,FIXED,DIPPED MICA, 82 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-820EJ0	DM15E820J0500WV4CR	72136	1
A2A8C18 AND C19	SAME AS C1			
A2A8C20	SAME AS A2A8C2			
A2A8C21	SAME AS A2A8C1			
A2A8J1 THRU J3	SAME AS A2A1J1			
A2A8L1	INDUCTOR,VARIABLE	132-0228-001	16665	1
A2A8L2	INDUCTOR,SHIELDED, 5.6 UH SINGER PART NO. 556200-006	DINK-5.6	78526	2
A2A8L3	COIL	132-0240-001	16665	1
A2A8L4	INDUCTOR,VARIABLE	132-0229-001	16665	1
A2A8L5	SAME AS A2A8L2			
A2A8L6	SAME AS A2A8L4			
A2A8L7	SAME AS A2A8L2			
A2A8L8	SAME AS A2A8L1			
A2A8Q1 AND Q2	SAME AS A2A1Q1			
A2A8Q3	TRANSISTOR SINGER PART NO. 556146-683	SE-5001	07263	1
A2A8Q4	SAME AS A2A1Q1			
A2A8R1	SAME AS A2A3R10			
A2A8R2	SAME AS A2A3R8			
A2A8R3	SAME AS A2A3R10			
A2A8R4	SAME AS R19			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A8R5 THRU	SAME AS R13			
A2A8R8	SAME AS A2A1R1			
A2A8R9	SAME AS R13			
A2A8R10	SAME AS A2A1R1			
A2A8R11	RESISTOR,FIXED,COMP., 75 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-750J	CB7505	01121	1
A2A8R12	SAME AS A2A1R1			
A2A8R13	SAME AS R19			
A2A8R14	RESISTOR,FIXED,COMP., 510 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-511J	CB5105	01121	1
A2A8R15	SAME AS A2A4R1			
A2A8R16	RESISTOR,FIXED,COMP., 910 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-911J	CB9115	01121	1
A2A8R17	SAME AS A2A3R5			
A2A8R18 AND R19	SAME AS R13			
A2A8R20	SAME AS R19			
A2A8R21	RESISTOR,VARIABLE, 100 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-007	UHT201-2/100,20PCT	11236	1
A2A9	60/6.5-MHZ CONVERTER ASSY	103-1560-002	16665	1
A2A9C1 AND C2	SAME AS C1			
A2A9C3	CAPACITOR,FIXED,DIPPED MICA, 270PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-271EJ0	DM15E271J0500WV4CR	72136	1
A2A9C4	SAME AS A2A1C20			
A2A9C5	SAME AS A2A7C13			
A2A9C6	CAPACITOR,FIXED,DIPPED MICA, 62 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-620EJ0	DM15E620J0500WV4CR	72136	1
A2A9C7	CAPACITOR,FIXED,DIPPED MICA, 75 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-750EJ0	DM15E750J0500WV4CR	72136	1
A2A9C8	CAPACITOR,FIXED,DIPPED MICA, 68 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-680EJ0	DM15E680J0500WV4CR	72136	1
A2A9C9 AND C10	SAME AS A2A1C9			
A2A9C11	CAPACITOR,FIXED,DIPPED MICA 200PF PORM5PCT SINGER PART NO. 150-2002-201EJ0	DM15F201J0500WV4CR	72136	
A2A9C12	SAME AS A2A1C9			
A2A9C13	SAME AS C1			
A2A9C14	SAME AS A2A1C14			
A2A9C15	SAME AS A2A1C16			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2A9C16	SAME AS A2A1C14			
A2A9J1 AND J2	SAME AS A2A1J1			
A2A9L1	INDUCTOR,VARIABLE	132-0230-001	16665	1
A2A9Q1 AND Q2	SAME AS A2A1Q1			
A2A9R1	SAME AS A2A1R1			
A2A9R2 AND R3	SAME AS R13			
A2A9R4	SAME AS R19			
A2A9R5	SAME AS R47			
A2A9R6 AND R7	SAME AS R13			
A2A9R8	SAME AS A2A3R8			
A2A9R9	SAME AS R19			
A2A9R10	SAME AS A2A1R6			
A2A9R11	SAME AS A2A1R7			
A2A9R12	SAME AS A2A1R6			
A2A9T1	TRANSFORMER,VARIABLE	132-0232-001	16665	1
A2A9T2 AND T3	TRANSFORMER,VARIABLE	132-0231-001	16665	1
A2A9Y1	CRYSTAL,53.5 MHZ SINGER PART NO. 556146-692	CR55/U 53.5 MHZ	81349	1
A3	BACK IF ASSY	103-1585-002	16665	1
A3C1 THRU C14	CAPACITOR,FIXED,FEED-THRU, 0.02 UF,PLUS 80, MINUS 20 PCT, SINGER PART NO. 556202-001	533C14A	56289	2
A3C15 THRU C24	SAME AS A2A7C1			
A3C25 AND C26	SAME AS A2C1			
A3J1	CONNECTOR,PLUG SINGER PART NO. 556146-752	SM14-20PGD	95238	1
A3J2 THRU A3J5	SAME AS A2J2			
A3P1	CONNECTOR,PLUG, 4 TERMINALS	128-1037-001	16665	1
A3P2	CONNECTOR,PLUG, 2 TERMINALS	128-1036-011	16665	1
A3P3	CONNECTOR,PLUG, 7 TERMINALS	128-1036-001	16665	1
A3P4	CONNECTOR,PLUG, 3 TERMINALS	128-1036-007	16665	1
A3P5	CONNECTOR,PLUG, 3 TERMINALS	128-1036-006	16665	1
A3P6	SAME AS A2P4		16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3P7 THRU P10	SAME AS A2P9			
A3W2	SAME AS A2W2			
A3W2P1 AND P2	SAME AS A2P9			
A3W3	CABLE ASSY	102-9200-411	16665	1
A3W3P1 AND P2	SAME AS A2P9			
A3W4	CABLE ASSY	102-9200-412	16665	1
A3W4P1 AND P2	SAME AS A2P9			
A3W5	CABLE ASSY	102-9200-413	16665	1
A3W5P1 AND P2	SAME AS A2P9			
A3W7	CABLE ASSY	102-9200-414	16665	1
A3W7P1 AND P2	SAME AS A2P9			
A3A1	6.5-MHZ WIDEBAND FILTER ASSY	103-1561-002	16665	1
A3A1CR1 THRU CR4	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-046	IN251	93332	2
A3A1C1 AND C2	SAME AS A2A1C9			
A3A1C3 AND C4	SAME AS A2A7C1			
A3A1C5 THRU C7	SAME AS A2A1C9			
A3A1C8	SAME AS A2A8C2			
A3A1C9	SAME AS A2A1C19			
A3A1C10 AND C11	SAME AS A2A1C9			
A3A1C12 AND C13	SAME AS A2A7C1			
A3A1J1 THRU J3	SAME AS A2A1J1			
A3A1L1	SAME AS A2A8L2			
A3A1L2	INDUCTOR,SHIELDED, 220 UH,PORM 5 PCT SINGER PART NO. 556200-011	D1NK-220	78526	1
A3A1Q1	SAME AS A2A1Q1			
A3A1R1	SAME AS R49			
A3A1R2	SAME AS A2A4R2			
A3A1R3	SAME AS R49			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A1R4	SAME AS A2A3R9			
A3A1R5	SAME AS R19			
A3A1R6	SAME AS A2A3R9			
A3A1R7	SAME AS R19			
A3A1R8	SAME AS R50			
A3A1R9	SAME AS R22			
A3A1R10	RESISTOR,FIXED,COMP., 6800 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-682J	CB6825	01121	1
A3A1R11	SAME AS A2A8R21			
A3A1R12	SAME AS R13			
A3A2	6.5-MHZ NARROWBAND FILTER ASSY	103-1562-002	16665	1
A3A2C1	SAME AS A2A1C9			
A3A2C2	CAPACITOR FIXED 0.1UF 25V SINGER PART NO. 556120-162	5C023104X0250B3	56289	1
A3A2C3	CAPACITOR,VARIABLE 7 TO 45 PF SINGER PART NO. 556122-090	503-041E2P033R	72982	1
A3A2C4	CAPACITOR,FIXED,DIPPED MICA, 180PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-181EJ0	DM15E181J0500WV4CR	72136	1
A3A2C5	SAME AS A3A2C3			
A3A2C6	SAME AS A3A2C4			
A3A2C7	SAME AS A3A2C3			
A3A2C8	SAME AS A3A2C4			
A3A2C9	SAME AS A3A2C3			
A3A2C10	SAME AS A3A2C4			
A3A2C11	SAME AS A2A3C3			
A3A2C12	SAME AS A3A2C4			
A3A2C13	SAME AS A3A2C3			
A3A2C14	SAME AS A3A2C4			
A3A2C15	SAME AS A3A2C3			
A3A2C16	SAME AS A3A2C4			
A3A2C17	SAME AS A3A2C3			
A3A2C18	SAME AS A3A2C4			
A3A2C19 AND C20	SAME AS A2A1C9			
A3A2C21 THRU C24	SAME AS A3A7C1			
A3A2J1 AND J2	SAME AS A2A1J1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A2L1	INDUCTOR,VARIABLE	132-0233-001	16665	1
A3A2L2	SAME AS A2A1L6			
A3A2L3	SAME AS A3A2L1			
A3A2L4	SAME AS A2A1L6			
A3A2L5	SAME AS A3A2L1			
A3A2L6	SAME AS A2A1L6			
A3A2L7	SAME AS A3A2L1			
A3A2L8	SAME AS A2A1L6			
A3A2L9	SAME AS A3A2L1			
A3A2L10	SAME AS A2A1L6			
A3A2L11	SAME AS A3A2L1			
A3A2L12	SAME AS A2A1L6			
A3A2L13	SAME AS A3A2L1			
A3A2L14	SAME AS A2A1L6			
A3A2L15	SAME AS A3A2L1			
A3A2L16 AND L17	SAME AS A3A1L2			
A3A2Q1 AND Q2	TRANSISTOR SINGER PART NO. 556146-677	2N3694	81349	1
A3A2R1	SAME AS R50			
A3A2R2 AND R3	RESISTOR,FIXED,COMP., 6200 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-622J	CB6225	01121	
A3A2R4	SAME AS R50			
A3A2R5	SAME AS A2A1R17			
A3A2R6	SAME AS R22			
A3A2R7	SAME AS A2A8R14			
A3A2R8 AND R9	SAME AS R28			
A3A2R10	SAME AS A2A1R17			
A3A3	6.5-MHZ VARIABLE BANDWIDTH AMPLIFIER ASSY	103-1563-002	16665	1
A3A3CR1 THRU CR4	SAME AS A3A1CR1			
A3A3C1 THRU C4	SAME AS A2A1C8			
A3A3C5	SAME AS A2A1C19			
A3A3C6 THRU C10	SAME AS A2A1C8			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A3C11	SAME AS A2A1C19			
A3A3C12	SAME AS A3A7C1			
A3A3C13	CAPACITOR,VARIABLE, 2.5 TO 11 PF SINGER PART NO. 150-0008-003	538-011B2.2-11	72982	1
A3A3C15 AND C16	SAME AS A2A1C8			
A3A3C17	SAME AS A2A1C9			
A3A3C18	SAME AS A2A1C8			
A3A3C19	SAME AS A2A7C1			
A3A3C20 AND C21	SAME AS A2A1C8			
A3A3C22	SAME AS A2A8C17			
A3A3C23	SAME AS A2A1C19			
A3A3C25	SAME AS A2A1C8			
A3A3C26	SAME AS A3A3C13			
A3A3C27	SAME AS A3A3C11			
A3A3C28	SAME AS A2A1C8			
A3A3C30 AND C31	SAME AS A2A1C8			
A3A3C34 THRU C37	SAME AS A2A7C1			
A3A3C38 THRU C41	SAME AS A2A1C8			
A3A3C42 AND C43	SAME AS A2A7C1			
A3A3C44	CAPACITOR,FIXED,CERAMIC, 12 PF,PORM 10 PCT SINGER PART NO. 556147-249	301N75012PFPORM10PCT	72982	1
A3A3C45	SAME AS A2A1C9			
A3A3C46	SAME AS A3A3C44			
A3A3C47	SAME AS A2A1C9			
A3A3J1 THRU J3	SAME AS A2A1J1			
A3A3L1	INDUCTOR,SHIELDED, 10 UH SINGER PART NO. 556200-008	DINK-10	78526	1
A3A3L2 THRU L4	SAME AS A2A1L6			
A3A3L5	INDUCTOR,VARIABLE	132-0324-001	16665	1
A3A3L6	SAME AS A2A1L6			
A3A3L8	SAME AS A2A1L6			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A3L10	INDICTOR,SHIELDED, 4.7 UH SINGER PART NO. 556200-005	DINK-4.7	78526	1
A3A3L12	SAME AS A3A3L5			
A3A3L14 AND L15	SAME AS A2A1L6			
A3A3L16 AND L17	SAME AS A3A1L2			
A3A3Q1	SAME AS A3A2Q1			
A3A3Q2 AND Q3	TRANSISTOR SINGER PART NO. 556146-672	2N3015	81349	1
A3A3Q4 THRU Q7	SAME AS A3A2Q1			
A3A3Q8	SAME AS A2A7Q1			
A3A3R1	SAME AS A2A1R1			
A3A3R2 AND R3	SAME AS R28			
A3A3R4	SAME AS A2A1R12			
A3A3R5	RESISTOR,FIXED,COMP., 1000 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-102J	EB1025	01121	1
A3A3R6	SAME AS R19			
A3A3R7	SAME AS A2A1R1			
A3A3R8 AND R9	RESISTOR,FIXED,COMP., 2400 OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-242J	CB2425	01121	3
A3A3R10	SAME AS A2A3R9			
A3A3R11	SAME AS R19			
A3A3R12	SAME AS A2A1R1			
A3A3R13	RESISTOR,FIXED,COMP., 3.9K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-392J	EB392	01121	1
A3A3R14	SAME AS R19			
A3A3R15	RESISTOR,FIXED,COMP., 180 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-181J	GB1815	01121	1
A3A3R16	RESISTOR,FIXED,COMP., 270 OHMS,PORM 5 PCT,1W SINGER PART NO. 151-1004-271J	GB2715	01121	1
A3A3R17	RESISTOR,PHOTO-CONTROLLED SINGER PART NO. 556146-747	CK1121	49956	1
A3A3R18 AND R19	RESISTOR,FIXED,COMP., 2.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-222J	CB2225	01121	1
A3A3R20	SAME AS R13			
A3A3R21	SAME AS R19			
A3A3R22	RESISTOR,FIXED,COMP., 11K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-113J	CB1135	01121	2

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A3R23	SAME AS A2A1R10			
A3A3R24	RESISTOR,FIXED,COMP., 82 OHMS,PORM 5 PCT 1/4W SINGER PART NO. 151-1002-820J	CB8205	01121	1
A3A3R25	RESISTOR,VARIABLE, 250 OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-001	UHT201-2/250,20PCT	11236	1
A3A3R26	SAME AS R13			
A3A3R27	SAME AS R19			
A3A3R28	SAME AS A2A1R1			
A3A3R29	RESITOR FIXED,COMP.,270 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-271J	CB2715	01121	1
A3A3R30	SAME AS A2A3R5			
A3A3R31	SAME AS R49			
A3A3R32	RESISTOR,FIXED,COMP., 1200 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-122J	EB1225	01121	1
A3A3R33	SAME AS A3A3R17			
A3A3R34	SAME AS R19			
A3A3R35	SAME AS R47			
A3A3R36	SAME AS R19			
A3A3R37	SAME AS A3A3R8			
A3A3R38	RESISTOR,FIXED,COMP., 1.2K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-122J	CB1225	01121	3
A3A3R39	SAME AS A3A3R8			
A3A3R40	SAME AS A3A3R38			
A3A3R41	SAME AS R19			
A3A3R42	SAME AS A3A3R18			
A3A3R43	SAME AS A2A7R20			
A3A3R44	SAME AS A2A7R3			
A3A3Y1	CRYSTAL, 6.5 MHZ	134-0033-001	16665	1
A3A3Y2	CRYSTAL, 6.5 MHZ	134-0033-002	16665	1
A3A4	LOG AMPLIFIER ASSY	103-1564-002	16665	1
A3A4CR1 THRU CR6	SAME AS A3A1CR1			
A3A4C1	SAME AS A2A1C8			
A3A4C3	CAPACITOR,FIXED,DIPPED MICA,1000PF,PORM 5 PCT,500V SINGER PART NO. 150-2003-102EJ0	DM19E102J0500WV4CR	72136	1
A3A4C4	SAME AS A2A1C8			
A3A4C5	SAME AS A2A9C7			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4C6	SAME AS A2A1C19			
A3A4C7	CAPACITOR,FIXED,DIPPED MICA, 12 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-120EJO	DM15E120J0500WV4CR	72136	1
A3A4C8	SAME AS A2A8C16			
A3A4C9	SAME AS A2A1C9			
A3A4C10	SAME AS A3A4C3			
A3A4C11	SAME AS A2A1C8			
A3A4C12	SAME AS A2A1C19			
A3A4C13	CAPACITOR,FIXED,DIPPED MICA, 51 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-510EJO	DM15E510J0500WV4CR	72136	
A3A4C14	SAME AS A2A8C16			
A3A4C15	CAPACITOR,FIXED,DIPPED MICA, 24 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-240EJO	DM15E240J0500WV4CR	72136	1
A3A4C16	SAME AS A2A1C19			
A3A4C17	SAME AS A3A4C3			
A3A4C18	SAME AS A2A1C8			
A3A4C19	SAME AS A2A1C9			
A3A4C20	SAME AS A3A4C13			
A3A4C21	SAME AS A2A8C16			
A3A4C22	SAME AS A3A4C15			
A3A4C23	SAME AS A2A1C9			
A3A4C24	SAME AS A3A4C3			
A3A4C25	SAME AS A2A1C8			
A3A4C26	SAME AS A2A1C19			
A3A4C27	SAME AS A2A4C2			
A3A4C28	SAME AS A2A7C1			
A3A4C29	SAME AS A2A1C21			
A3A4C30	SAME AS A2A8C16			
A3A4C31	SAME AS A3A4C15			
A3A4C32	SAME AS A2A1C9			
A3A4C33	SAME AS A3A4C3			
A3A4C34	SAME AS A2A1C8			
A3A4C35	SAME AS A2A9C7			
A3A4C36	SAME AS A2A1C19			
A3A4C37	SAME AS A2A8C16			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4C38	SAME AS A3A4C15			
A3A4C39	SAME AS A2A1C9			
A3A4C40	SAME AS A3A4C3			
A3A4C41	SAME AS A2A1C8			
A3A4C42	SAME AS A2A7C1			
A3A4C43	SAME AS A3A4C13			
A3A4C44	SAME AS A2A1C19			
A3A4C45	SAME AS A2A8C16			
A3A4C46	SAME AS A3A4C15			
A3A4C47	SAME AS A3A4C7			
A3A4C48 THRU C50	SAME AS A2A7C1			
A3A4J1 THRU J3	SAME AS A2A1J1			
A3A4L1	SAME AS A2A8L2			
A3A4L2	SAME AS A2A1L6			
A3A4L3	SAME AS A2A8L2			
A3A4L4	INDUCTOR,SHIELDED, 27 UH SINGER PART NO. 556200-009	DINK-27	78526	2
A3A4L5	SAME AS A2A1L6			
A3A4L6	SAME AS A2A8L2			
A3A4L7	SAME AS A3A4L4			
A3A4L8	SAME AS A2A1L6			
A3A4L9	SAME AS A2A8L2			
A3A4L10	SAME AS A3A4L4			
A3A4L11	SAME AS A2A1L6			
A3A4L12	SAME AS A2A8L2			
A3A4L13	SAME AS A3A4L4			
A3A4L14	SAME AS A2A1L6			
A3A4L15	SAME AS A2A8L2			
A3A4L16	SAME AS A3A4L4			
A3A4L17	SAME AS A3A1L2			
A3A4L18	SAME AS A3A4L4			
A3A4L19 AND L20	SAME AS A3A1L2			
A3A4Q1	TRANSISTOR SINGER PART NO. 556146-681	SE-3002	07263	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4Q2 AND Q3	TRANSISTOR SINGER PART NO. 556146-375	2N3646	82389	2
A3A4Q4	SAME AS A3A2Q1			
A3A4Q5 THRU Q7	SAME AS A3A4Q2			
A3A4Q8	TRANSISTOR SINGER PART NO. 556146-674	2N3568	81349	1
A3A4Q9	TRANSISTOR SINGER PART NO. 556146-255	2N3638	07263	2
A3A4R1	SAME AS A2A1R1			
A3A4R2	SAME AS R22			
A3A4R3	RESISTOR,FIXED,COMP., 7500 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-752J	CB7525	01121	2
A3A4R4	SAME AS R50			
A3A4R5	SAME AS A2A4R1			
A3A4R6	SAME AS A2A1R9			
A3A4R7	SAME AS R19			
A3A4R8	SAME AS R28			
A3A4R9	SAME AS A2A3R6			
A3A4R10	SAME AS R22			
A3A4R11	SAME AS A3A4R3			
A3A4R12	RESISTOR,FIXED,COMP., 33 OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-330J	CB3305	01121	1
A3A4R13	SAME AS A2A4R1			
A3A4R14	SAME AS A2A1R9			
A3A4R15	SAME AS R28			
A3A4R16	SAME AS A2A3R6			
A3A4R17	SAME AS R22			
A3A4R18	SAME AS A3A4R3			
A3A4R19	SAME AS A3A4R12			
A3A4R20	SAME AS A2A4R1			
A3A4R21	SAME AS A2A1R9			
A3A4R22	SAME AS R28			
A3A4R23	SAME AS A2A3R6			
A3A4R24	SAME AS R22			
A3A4R25	SAME AS A3A4R3			
A3A4R26	SAME AS A3A4R12			
A3A4R27	SAME AS A2A4R1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A4R28	SAME AS A2A1R9			
A3A4R29	SAME AS R28			
A3A4R30 AND R31	SAME AS A2A7R20			
A3A4R32	SAME AS A2A1R1			
A3A4R33	SAME AS R19			
A3A4R34	SAME AS A2A3R6			
A3A4R35	SAME AS R22			
A3A4R36	SAME AS A3A4R3			
A3A4R37	SAME AS A3A4R12			
A3A4R38	SAME AS A2A4R1			
A3A4R39	SAME AS A2A1R9			
A3A4R40	SAME AS R28			
A3A4R41	SAME AS A2A3R6			
A3A4R42	SAME AS A3A4R3			
A3A4R43	SAME AS R22			
A3A4R44	SAME AS A2A8R21			
A3A4R45	SAME AS A2A4R1			
A3A4R46	SAME AS A2A1R9			
A3A4R47	SAME AS R28			
A3A4R48	RESISTOR,VARIABLE, 1000 OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-003	UHT201-2/1K,20PCT	11236	1
A3A4R49	SAME AS A2A1R10			
A3A4R50	SAME AS A2A4R5			
A3A4R51	SAME AS A2A1R10			
A3A4R52	SAME AS A2A1R6			
A3A5	LIN/POWER AMPLIFIER ASSY	103-1565-002	16665	1
A3A5CR1	SAME AS A2A2CR1			
A3A5CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-105	IN749	81483	1
A3A5C1	SAME AS A2A1C21			
A3A5C2	SAME AS A2A1C19			
A3A5C3	SAME AS C1			
A3A5C4	SAME AS A2A1C8			
A3A5C5	SAME AS A2A1C9			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A5C6	SAME AS A2A1C8			
A3A5C7	SAME AS A2A7C13			
A3A5C8	SAME AS A2A1C14			
A3A5C9 THRU C12	SAME AS A2A1C8			
A3A5J1 THRU J3	SAME AS A2A1J1			
A3A5L1	SAME AS A3A3L1			
A3A5L2 THRU L5	SAME AS A2A1L6			
A3A5Q1	TRANSISTOR SINGER PART NO. 556146-675	2N3641	81349	1
A3A5Q2	SAME AS A3A4Q8			
A3A5Q3 AND Q4	SAME AS A3A4Q9			
A3A5Q5	TRANSISTOR SINGER PART NO. 556146-686	U148	17856	1
A3A5Q6	SAME AS A3A4Q8			
A3A5Q7	SAME AS A3A4Q9			
A3A5R1 AND R2	SAME AS R32			
A3A5R3	SAME AS R50			
A3A5R4	SAME AS A2A3R10			
A3A5R5 AND R6	SAME AS A2A7R4			
A3A5R7	SAME AS R28			
A3A5R8	SAME AS A3A4R48			
A3A5R9 AND R10	SAME AS A2A1R10			
A3A5R11	SAME AS A3A3R25			
A3A5R13	SAME AS A2A1R10			
A3A5R14	SAME AS A2A3R9			
A3A5R15	SAME AS A2A7R4			
A3A5R16	RESISTOR,FIXED,COMP.,2K OHMS PORM 5PCT 1/4W SINGER PART NO. 150-1002-202J	CB2025	01121	1
A3A5R17	RESISTOR,VARIABLE, 5K OHMS,PORM 20 PCT,1/4W SINGER PART NO. 151-0021-005	UHT201-2/5K,20PCT	11236	1
A3A5R18	SAME AS A2A7R25			
A3A5R19 AND R20	SAME AS A2A1R10			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3A5R21	SAME AS A2A7R14			
A4	DEFLECTION AMPLIFIER ASSY	103-1566-001	16665	1
A4C1	CAPACITOR,FIXED,DIPPED MICA, 750 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-751EJ0	DM15E751J0500WV4CR	72136	1
A4C2 THRU C3	SAME AS A2A1C18			
A4C4	SAME AS A4C1			
A4Q1 AND Q2	SAME AS A3A2Q1			
A4Q3	SAME AS A3A4Q9			
A4Q4 AND Q5	SAME AS A3A2Q1			
A4Q6	SAME AS A3A4Q9			
A4Q7	SAME AS A3A5Q1			
A4Q8 AND Q9	TRANSISTOR SINGER PART NO. 556146-673	2N3440	81349	1
A4Q10	SAME AS A3A5Q1			
A4Q11 AND Q12	SAME AS A4Q8			
A4R1	RESISTOR,VARIABLE, 100K OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-009	UHT201-2/100K,20PCT	11236	1
A4R2	SAME AS R32			
A4R3	SAME AS R22			
A4R4	SAME AS A3A3R22			
A4R5	SAME AS R22			
A4R6	RESISTOR,FIXED,COMP., 820 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-821J	CB8215	01121	1
A4R7	SAME AS R46			
A4R8	SAME AS R13			
A4R9	SAME AS R25			
A4R10	SAME AS R22			
A4R11	SAME AS A3A3R22			
A4R12	SAME AS R28			
A4R13	SAME AS R22			
A4R14	SAME AS R46			
A4R15	SAME AS R13			
A4R16	SAME AS A3A3R8			
A4R17	SAME AS A3A3R38			

TABLE 6-2. PARTS LIST

Ref Symbol		Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A4R18		SAME AS A2A1R13			
A4R19 R20	AND	RESISTOR,FIXED,COMP., 270 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-271J	CB2715	01121	1
A4R21 R22	AND	RESISTOR,FIXED,WIRE-WOUND, 10K OHMS,PORM 5 PCT,10W SINGER PART NO. 556045-003	247E1035	56289	1
A4R23		RESISTOR,FIXED,COMP., 20K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-203J	CB2035	01121	1
A4R24		SAME AS A3A2R2			
A4R25		SAME AS R19			
A4R26 R27	AND	SAME AS A3A3R38			
A4R28 R29	AND	RESISTOR,FIXED,COMP., 51K OHMS ,PORM 5 PCT 2W SINGER PART NO. 151-1005-513J	HB5135	01121	1
A4R30		RESISTOR,VARIABLE, 2.5K OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-010	UHT201-2/2.5K,20PCT	11236	1
A4R31 R32	AND	SAME AS R46			
A5		SAWTOOTH/INTENSFIER ASSY	103-1568-002	16665	1
A5CR1 CR3	THRU	SAME AS A2A2CR1			
A5CR4		SAME AS A3A5CR2			
A5CR5 CR6	AND	SAME AS A2A2CR1			
A5C1		CAPACITOR,FIXED,DIPPED MICA, 130PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-131EJ0	DM15E131J0500WV4CR	72136	1
A5C2 C3	AND	CAPACITOR,FIXED,DIPPED MICA, 110PF,PORM 5 PCT, 500V SINGER PART NO. 150-2002-111EJ0	DM15E111J0500WV4CR	72136	1
A5C4		SAME AS C1			
A5C5		SAME AS A2A1C8			
A5C6		SAME AS A5C1			
A5C7		SAME AS C2			
A5Q2		SAME AS A3A2Q1			
A5Q3		SAME AS A3A5Q1			
A5Q4 Q5	AND	SAME AS A3A4Q2			
A5Q6		SAME AS A3A4Q9			
A5Q7		SAME AS A3A5Q1			
A5Q8 Q9	AND	SAME AS A4Q8			
A5Q10 Q12	THRU	SAME AS A3A4Q2			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5Q13 AND Q14	SAME AS A3A4Q9			
A5Q15	TRANSISTOR SINGER PART NO. 556146-670	2N1480	81349	1
A5Q16	TRANSISTOR SINGER PART NO. 556146-929	2N2945	81349	1
A5Q17	SAME AS A3A4Q9			
A5Q18	SAME AS A3A5Q1			
A5Q19 THRU Q28	SAME AS A3A4Q2			
A5Q29	TRANSISTOR SINGER PART NO. 153-0001-001	2N5306	81349	
A5Q30	SAME AS A3A4Q9			
A5Q31 THRU Q33	SAME AS A3A4Q2			
A5Q34 AND Q35	SAME AS A5Q29			
A5Q36 THRU Q39	SAME AS A3A4Q2			
A5Q40	SAME AS A3A4Q9			
A5R2	SAME AS R19			
A5R3	SAME AS A2A3R9			
A5R4	SAME AS A2A1R6			
A5R5	SAME AS A3A1R10			
A5R6	SAME AS R28			
A5R7	SAME AS R19			
A5R8	SAME AS A3A3R8			
A5R10	SAME AS A2A7R15			
A5R11	SAME AS R19			
A5R12	SAME AS A3A3R18			
A5R13	SAME AS R22			
A5R14	SAME AS A4R6			
A5R15	SAME AS A2A3R9			
A5R16	RESISTOR,FIXED,COMP., 47K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-473J	HB4735	01121	1
A5R17	RESISTOR,FIXED,COMP., 30K OHMS PORM 5PCT 5W SINGER PART NO. 151-2002-303J	5XM30000	63743	1
A5R18	SAME AS R19			
A5R19	SAME AS A2A7R4			
A5R20	SAME AS R19			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R21	SAME AS A2A1R10			
A5R22	SAME AS A4R23			
A5R23 AND R24	SAME AS R24			
A5R25	SAME AS A2A1R10			
A5R26	SAME AS A4R23			
A5R27	SAME AS R19			
A5R28	SAME AS A3A3R38			
A5R29	SAME AS R19			
A5R30	SAME AS A3A4R3			
A5R31	SAME AS R19			
A5R32	SAME AS A3A1R10			
A5R33	SAME AS A3A3R8			
A5R34	SAME AS R19			
A5R35	RESISTOR,FIXED,COMP., 3600 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-362J	CB3625	01121	1
A5R36	SAME AS A2A7R4			
A5R37	SAME AS A3A4R48			
A5R38	SAME AS R19			
A5R39 AND R40	SAME AS R13			
A5R41	SAME AS A2A7R15			
A5R42	SAME AS R19			
A5R43 AND R44	SAME AS R13			
A5R45	SAME AS A2A7R15			
A5R46 AND R47	SAME AS R19			
A5R48 AND R49	SAME AS R13			
A5R50	SAME AS A2A7R15			
A5R51 THRU R53	SAME AS R13			
A5R54	SAME AS A2A7R15			
A5R55	SAME AS R19			
A5R56 AND R57	SAME AS R13			
A5R58	SAME AS A2A7R15			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R59	SAME AS R19			
A5R60	SAME AS R13			
A5R61	SAME AS R19			
A5R62	SAME AS A2A7R15			
A5R63	SAME AS R19			
A5R64	SAME AS R13			
A5R65	SAME AS A2A7R15			
A5R66	SAME AS R13			
A5R67	SAME AS A2A7R15			
A5R68	SAME AS R19			
A5R69 THRU R71	SAME AS R13			
A5R72	SAME AS A2A7R15			
A5R73	SAME AS R19			
A5R74 AND R75	SAME AS R13			
A5R76	SAME AS A2A7R15			
A5R77	SAME AS R19			
A5R78	SAME AS A2A3R9			
A5R79	SAME AS R22			
A5R80	SAME AS A2A7R25			
A5R81	SAME AS R19			
A5R82	RESISTOR,FIXED,COMP., 4300 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-432J	CB4325	01121	1
A5R83	SAME AS R50			
A5R84	SAME AS A2A7R15			
A5R85	SAME AS R19			
A5R86	SAME AS R13			
A5R87	SAME AS A2A7R15			
A5R88	SAME AS R19			
A5R89	RESISTOR,FIXED,COMP., 100K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-104J	EB1045	01121	1
A5R90	SAME AS A2A3R9			
A5R91	SAME AS A2A7R3			
A5R92	SAME AS R28			
A5R93	SAME AS A2A3R9			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5R94	SAME AS R28			
A5R95	SAME AS A4R30			
A5R96	SAME AS R28			
A5R97	SAME AS R19			
A5R98	SAME AS A5R82			
A5R99	SAME AS R50			
A5R100	SAME AS A2A7R15			
A5R101	SAME AS R19			
A5R102	SAME AS A2A1R10			
A5R103	SAME AS A2A3R9			
A5R104	SAME AS A5R35			
A5R105	SAME AS R35			
A5R106	RESISTOR,FIXED,COMP., 5600 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-562J	CB5625	01121	1
A5R107	SAME AS R32			
A5R108	SAME AS A2A3R9			
A5R109	SAME AS R51			
A5R110	RESISTOR,FIXED,COMP., 43K OHMS ,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-433J	CB4335	01121	1
A5R111	RESISTOR,FIXED,COMP., 68K OHMS,PORM 5 PCT, 1W SINGER PART NO. 151-1004-683J	CB6835	01121	1
A5R112	SAME AS A5R106			
A6	CRT POWER SUPPLY ASSY	103-1567-002	16665	1
A6CR1 THRU CR3	SAME AS A3A1CR1			
A6CR4 THRU CR9	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-179	EH-300	83701	1
A6C1	CAPACITOR,FIXED,ELECTROLYTIC, 250 UF,PLUS 50 MINUS 10 PCT, 30V SINGER PART NO. 556201-102	39D257G030EL4	56289	1
A6C2 AND C3	CAPACITOR,FIXED,ELECTROLYTIC, 50 UF,PLUS 75 MINUS 10 PCT,15V SINGER PART NO. 150-5001-500DS	30D506G015DB4	56289	1
A6C4	SAME AS A2A1C8			
A6C5	CAPACITOR,FIXED,ELECTROLYTIC, 2 UF,PLUS 75, MINUS 10 PCT,15V SINGER PART NO. 150-5001-2R0DS	TE-1148	56289	1
A6C6 AND C7	CAPACITOR,FIXED,DIPPED MYLAR,0.0075 UF,100V SINGER PART NO. 556147-200	1DP-1-752	72136	1
A6C8 THRU C11	CAPACITOR,FIXED,CERAMIC, 0.01 UF,PORM 20 PCT 3000V SINGER PART NO. 150-1006-001	41C121A2	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A6C12	CAPACITOR,FIXED,CERAMIC DISC, 0.003 UF,GMV 1000V SINGER PART NO. 556146-697	DD302	71590	1
A6C13 THRU C18	SAME AS A6C8			
A6C19	CAPACITOR,FIXED,CERAMIC DISC, 0.05 UF,PLUS 80,MINUS 20 PCT,500V SINGER PART NO. 556074-055	33C58	56289	1
A6C20 AND C21	SAME AS A6C8			
A6C22 AND C23	CAPACITOR,FIXED 25PF 3KV SINGER PART NO. 556147-223	DD30-250	71590	1
A6C24 AND C25	CAPACITOR,FIXED,DIPPED MICA, 200 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-201FJ0	DM15F201J0500WW4CR	72136	1
A6L1 AND L2	CHOKE,RF, 0.5MH SINGER PART NO. 556146-700	670-2	04213	1
A6Q1 AND Q2	TRANSISTOR SINGER PART NO. 556147-198	2N4922	81349	1
A6Q3	TRANSISTOR SINGER PART NO. 556147-197	2N4870	81349	1
A6R1	RESISTOR,FIXED,COMP., 1MEGOHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-105J	CB1055	01121	1
A6R2	RESISTOR,FIXED,COMP., 200K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-204J	CB2045	01121	1
A6R3 AND R4	RESISTOR,FIXED,COMP., 1.5 K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	EB1525	01121	1
A6R5	THERMISTOR, 12 OHMS SINGER PART NO. 556146-901	B1204H	10646	1
A6R6	RESISTOR,FIXED,COMP., 220K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-224J	EB2245	01121	1
A6R7	RESISTOR,FIXED,WIRE-WOUND, 25 MEGOHM,PORM20 PCT,1W SINGER PART NO. 556146-911	MVX/25MEGPORM20PCT1W	75042	1
A6R8	RESISTOR,FIXED,COMP., 15K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-153J	EB1535	01121	1
A6R9	RESISTOR,FIXED,COMP., 220K OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-224J	CB2245	01121	1
A6R10	SAME AS A6R7			
A6R11	RESISTOR,FIXED,COMP., 1 MEGOHM ,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-105J	EB1055	01121	1
A6R12	RESISTOR,FIXED,COMP.,10K OHMS PORM 5PCT 1/2W SINGER PART NO. 151-1003-103J	EB1035	01121	1
A6R13 AND R14	RESISTOR,FIXED,COMP., 2.2MEGOHM,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-225J	EB2255	01121	1
A6R15 AND R16	RESISTOR,FIXED,COMP.,62K OHMS PORM 5PCT 1/2W SINGER PART NO. 151-1003-623J	EB6235	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A6T1	TRANSFORMER	132-0270-001	16665	1
A7	POWER SUPPLY RECTIFIER AND FILTER ASSY	103-1570-001	16665	1
A7CR1 AND CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-106	MV-10C	13327	1
A7CR3 THRU CR12	SEMICONDUCTOR DEVICE.DIODE SINGER PART NO. 556146-689	1N4089	81349	2
A7C1 AND C2	CAPACITOR,FIXED,ELECTROLYTIC, 50 UF,PLUS 75, MINUS 10 PCT,450V SINGER PART NO. 556201-105	39D506F450JP4	56289	1
A7C3	CAPACITOR,FIXED,ELECTROLYTIC, 130 UF,PLUS 50 MINUS 10 PCT,200V SINGER PART NO. 556201-104	39D137F200HL4	56289	1
A7C4 THRU C7	CAPACITOR,FIXED,ELECTROLYTIC, 2400 UF,PLUS 50,MINUS 10 PCT,30V SINGER PART NO. 556201-103	39D248G030JP4	56289	1
A7F1	FUSE,DELAY, 1/10 AMPS SINGER PART NO. 556146-887	MDL1/10	71400	5
A7F2	FUSE,DELAY, 2 AMP SINGER PART NO. 556006-021	313002	75915	3
A7F3	FUSE,DELAY, 1.25 AMPS SINGER PART NO. 556146-743	MDX1-1/4	71400	3
A7R1	RESISTOR,FIXED,WIRE-WOUND, 700 OHMS,PORM 5 PCT,5W SINGER PART NO. 556043-009	243E7015	56289	1
A7R2	REISTOR,FIXED,COMP., 560K OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-564J	GB5645	01121	1
A7R3	RESISTOR,FIXED,COMP., 100K OHMS,PORM 5 PCT, 1W SINGER PART NO. 151-1004-104J	GB1045	01121	1
A7R4 AND R5	SAME AS R51			
A7XF1 THRU XF3	CLIP,FUSE SINGER PART NO. 556146-716	6008-32A	91506	1
A8	POWER SUPPLY CONTROL ASSY	103-1569-001	16665	1
A8CR1 AND CR2	SAME AS A7CR3			
A8CR3	SAME AS CR1			
A8CR4 AND CR5	SAME AS A7CR3			
A8CR6	SAME AS CR1			
A8C1	SAME AS A7C3			
A8C2	SAME AS C1			
A8C3	SAME AS A2A1C9			
A8C4	CAPACITOR,FIXED,ELECTROLYTIC, 4 UF,PLUS 75 MINUS 10 PCT,150V SINGER PART NO. 150-5001-4ROHS	30D405G150DD4	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8C5	CAPACITOR,FIXED,ELECTROLYTIC, 1 UF,PLUS 75, MINUS 10 PCT,25V SINGER PART NO. 150-5001-1ROES	TE-1200	56289	1
A8C6 AND C7	CAPACITOR,FIXED,ELECTROLYTIC, 200 UF,PLUS 50 MINUS 10 PCT,25V SINGER PART NO. 556201-101	39D207G025EJ4	56289	1
A8C8	SAME AS A8C5			
A8C9 AND C10	SAME AS A8C6			
A8C11 AND C12	SAME AS C1			
A8Q1 THRU Q4	SAME AS A4Q8			
A8Q5	SAME AS A3A4Q9			
A8Q6 AND Q7	SAME AS A3A2Q1			
A8Q8	SAME AS A3A4Q9			
A8Q9 AND Q10	SAME AS A3A2Q1			
A8R1	SAME AS R32			
A8R2	SAME AS A3A2R2			
A8R3	SAME AS A2A1R1			
A8R4	SAME AS A3A4R3			
A8R5	RESISTOR,FIXED,COMP., 3.3 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-3R3J	CB3R35	01121	1
A8R6	SAME AS A2A1R1			
A8R7	RESISTOR,FIXED,COMP., 39K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-393J	CB3935	01121	1
A8R8	SAME AS A2A1R1			
A8R9	RESISTOR,FIXED,COMP., 2700 OHM,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-272J	CB2725	01121	1
A8R10	SAME AS A3A5R17			
A8R11	RESISTOR,FIXED,COMP., 15K OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-153J	GB1535	01121	1
A8R12	RESISTOR,FIXED,COMP., 560 OHMS ,PORM 5 PCT, 1W SINGER PART NO. 151-1004-561J	GB5615	01121	1
A8R13	SAME AS A2A4R1			
A8R14	SAME AS A3A3R38			
A8R15	SAME AS A2A1R1			
A8R16	SAME AS R46			
A8R17	SAME AS A2A1R1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8R18	SAME AS A3A3R8			
A8R19	SAME AS A2A7R14			
A8R20	SAME AS A8R9			
A8R21	SAME AS A8R12			
A8R22	SAME AS A2A4R1			
A8R23	SAME AS A3A3R38			
A8R24	SAME AS A2A1R1			
A8R25	SAME AS R46			
A8R26	SAME AS A2A1R1			
A8R27	SAME AS A3A3R18			
A8R28	SAME AS A2A7R14			
A8R29	SAME AS A8R9			
A8V1	LAMP,NEON,GLOW SINGER PART NO. 556146-578	Z82R7	74276	1
A9	AUXILIARY CONTROL ASSY	103-1574-002	16665	1
A9C1	CAPACITOR,FIXED 0.05UF 500V SINGER PART NO. 556074-055	33C58	56289	1
A9C2 AND C3	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF, PORM 20 PCT,200V SINGER PART NO. 556060-084	805-200V-Z5U-103M	72982	1
A9Q1 AND	SAME AS A3A5Q1			
A9Q3 AND Q4	SAME AS A3A4Q9			
A9Q5 AND Q6	SAME AS A3A5Q1			
A9Q7 AND Q8	SAME AS A3A4Q9			
A9Q9	SAME AS A2A1Q1			
A9Q10	SAME AS A3A5Q10			
A9R1	SAME AS R23			
A9R2	SAME AS A4R23			
A9R3	SAME AS R22			
A9R4	SAME AS A3A3R17			
A9R5	SAME AS R50			
A9R6	RESISTOR,FIXED,COMP., 100 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-101J	EB1015	01121	1
A9R7	SAME AS R28			
A9R8	SAME AS A3A5R17			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9R9	SAME AS A3A3R18			
A9R10	SAME AS R22			
A9R11	SAME AS A2A7R22			
A9R12	SAME AS R22			
A9R13	SAME AS A4R23			
A9R14	SAME AS R50			
A9R15	SAME AS R28			
A9R16	SAME AS A9R6			
A9R17	SAME AS A2A7R25			
A9R18 AND R19	RESISTOR,VARIABLE, 500K OHMS,PORM 20 PCT, 1/4W SINGER PART NO. 151-0021-012	UHT201-2/500K,20PCT	11236	1
A9R20	SAME AS A4R1			
A9R21	SAME AS A3A5R17			
A9R22	SAME AS R22			
A9R23	RESISTOR,FIXED,COMP.,24K OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-243J	CB2435	01121	1
A9R24	SAME AS A4R1			
A9R25	SAME AS A2A7R7			
A9R26	SAME AS A3A3R22			
A9R27	SAME AS A9R18			
A9R28	RESISTOR,FIXED,COMP., 470K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-474J	CB4745	01121	1
A9R29	SAME AS A3A3R8			
A9R30 AND R31	SAME AS R28			
A9R32	SAME AS R50			
A9R33	SAME AS A3A3R18			
A9R34	SAME AS R22			
A9R35	SAME AS R23			
A9R36	SAME AS R50			